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Data Acquisition and Processing Report

NOAA Ship *Ferdinand R. Hassler*
Chief of Party: LCDR Matthew J. Jaskoski, NOAA
Year: 2016
Version: 1.1
Publish Date: 2017-04-20

A Equipment

A.1 Survey Vessels

A.1.1 NOAA Ship FERDINAND R. HASSLER

Name	NOAA Ship FERDINAND R. HASSLER	
Hull Number	S250	
Description	FERDINAND R. HASSLER is a Small Waterplane Area, Twin-Hull (SWATH) coastal mapping vessel.	
Utilization	Survey	
Dimensions	*LOA*	37.7 meters
	Beam	18.5 meters
	Max Draft	3.85 meters
Most Recent Full Static Survey	*Date*	2009-11-04
	Performed By	Raymond C. Impastato, Professional Land Surveyor
	Discussion	This survey was provided by the shipbuilder, V.T. Halter Marine, and performed in the shipyard prior to delivery.
Most Recent Partial Static Survey	*Date*	2012-06-12
	Performed By	Kevin Jordan, NGS
	Discussion	This survey was performed after the POS/MV antenna mounts were reconfigured to newly fabricated mounts and ties the POS antennae into benchmarks on the 03 deck.

Most Recent Full Offset Verification	Full offset verification was not performed.	
Most Recent Partial Offset Verification	*Date*	2013-04-07
	Method Used	Optical level run while ship was out of the water in drydock
	Discussion	A level loop was run from the POS antenna to each sensor mounted on the ship's hull. In addition, measurements were made to both IMU base plates through the 7125 cable passage. The resulting offsets from this survey were used to verify and update Z offsets between all sensors.
Most Recent Static Draft Determination	*Date*	2011-07-12
	Method Used	Calculation from design waterline and measured offsets
	Discussion	Assumed design waterline of 3.8 meters and measured offsets to IMU were used to determine static draft of the reference point. The ship's draft is operationally managed with daily ballast to achieve a true waterline of 3.77 meters. Draft uncertainty is estimated at 0.05 meters. See Section C.2.1.1 for additional discussion.
Most Recent Dynamic Draft Determination	*Date*	2016-02-21
	Method Used	Ellipsoid referenced dynamic draft measurement (ERDDM)
	Discussion	Data were acquired with canards at zero trim angle. During all survey operations, the canards are set to zero trim angle. Averages are being calculated from all ERDDM tests since the installation of the buoyancy appendages in 2013. This will help filter out errors located in individual tests.

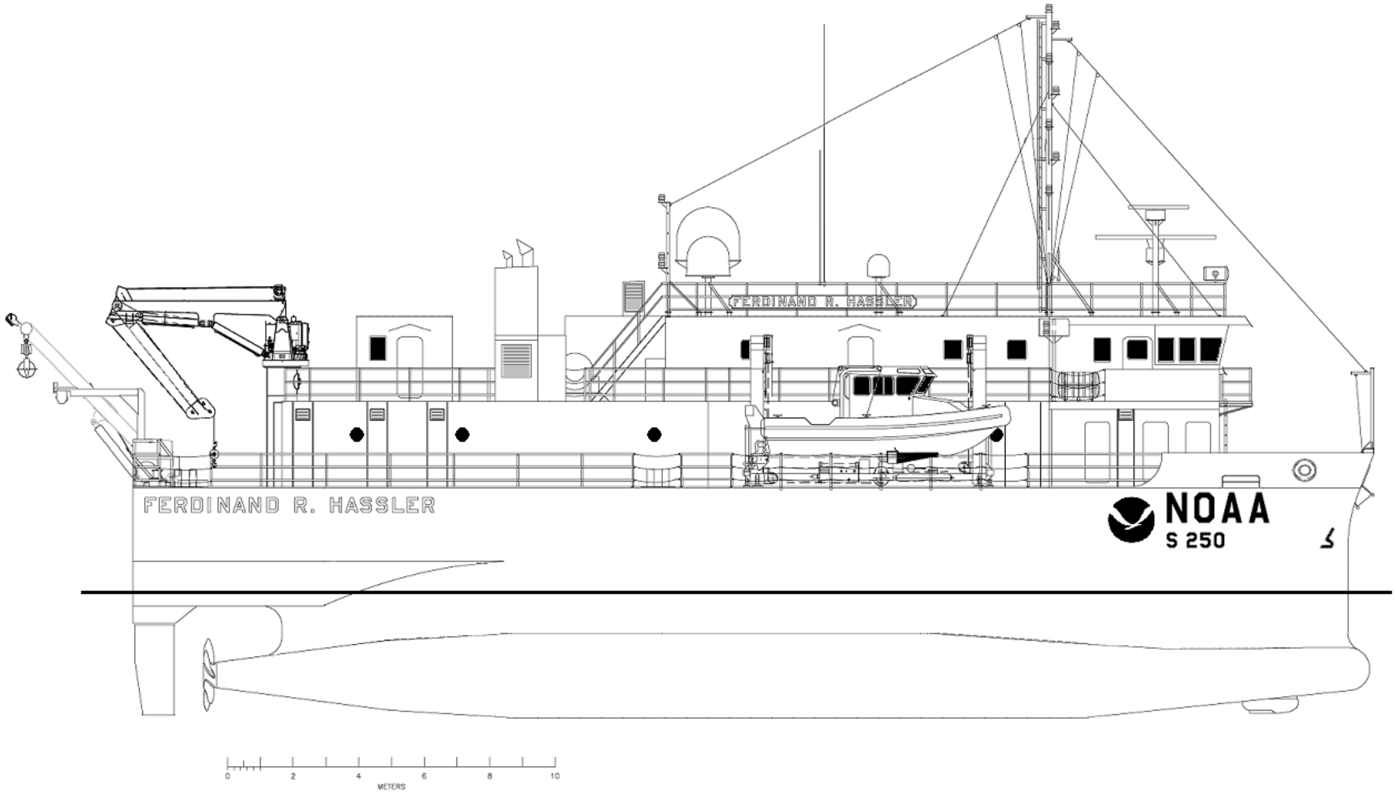


Figure 1: NOAA Ship FERDINAND R. HASSLER, Starboard View

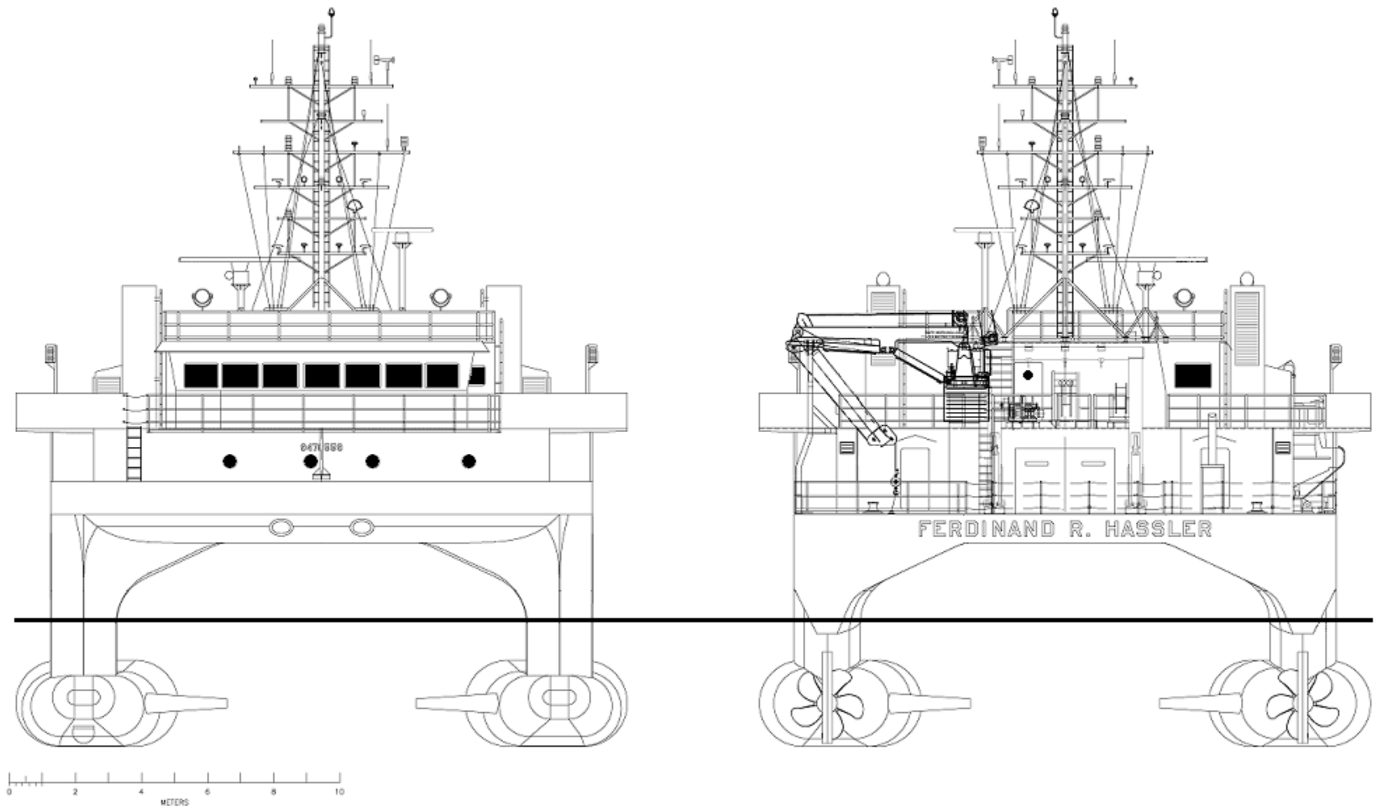
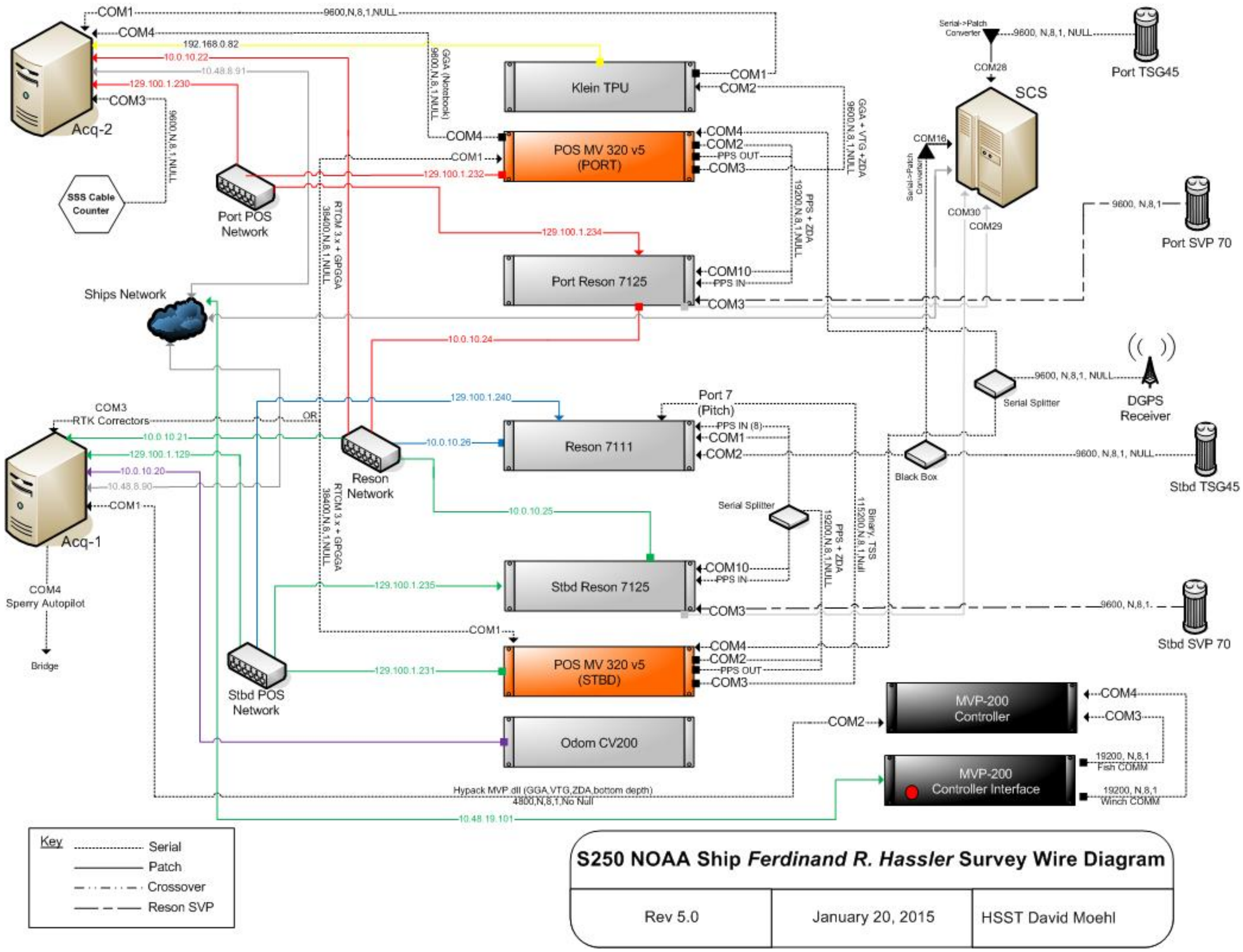


Figure 2: NOAA Ship FERDINAND R. HASSLER, Bow and Stern View



A.1.2 FH Launch 2702

Name	FH Launch 2702	
Hull Number	2702	
Description	25ft enclosed cabin survey launch made by North River, outfitted with jet drive propulsion and Yanmar diesel engine.	
Utilization	Near shore shallow water hydrographic survey vessel.	
Dimensions	*LOA*	7.62 meters
	Beam	3.05 meters
	Max Draft	0.76 meters

Most Recent Full Static Survey	*Date*	2015-06-16
	Performed By	Kevin Jordan, NGS
	Discussion	The intention of this survey was to accurately position the POS/MV IMU, GPS Antennas, Sonar Equipment, benchmarks, and reference marks located on the 2702 Launch.
Most Recent Partial Static Survey	Partial static survey was not performed.	
Most Recent Full Offset Verification	Full offset verification was not performed.	
Most Recent Partial Offset Verification	Partial offset verification was not performed.	
Most Recent Static Draft Determination	*Date*	2016-08-14
	Method Used	Bubble level and tape measure
	Discussion	The waterline was measured using a bubble level and tape measure to measure the vertical distance from the benchmarks to the waterline. The static draft was calculated using those values.
Most Recent Dynamic Draft Determination	*Date*	2016-03-03
	Method Used	Ellipsoid referenced dynamic draft measurement (ERDDM)
	Discussion	This was the first dynamic draft measurement performed on Launch 2702. Dynamic draft measurements will be performed on an annual basis and averaged to aid in filtering outliers.

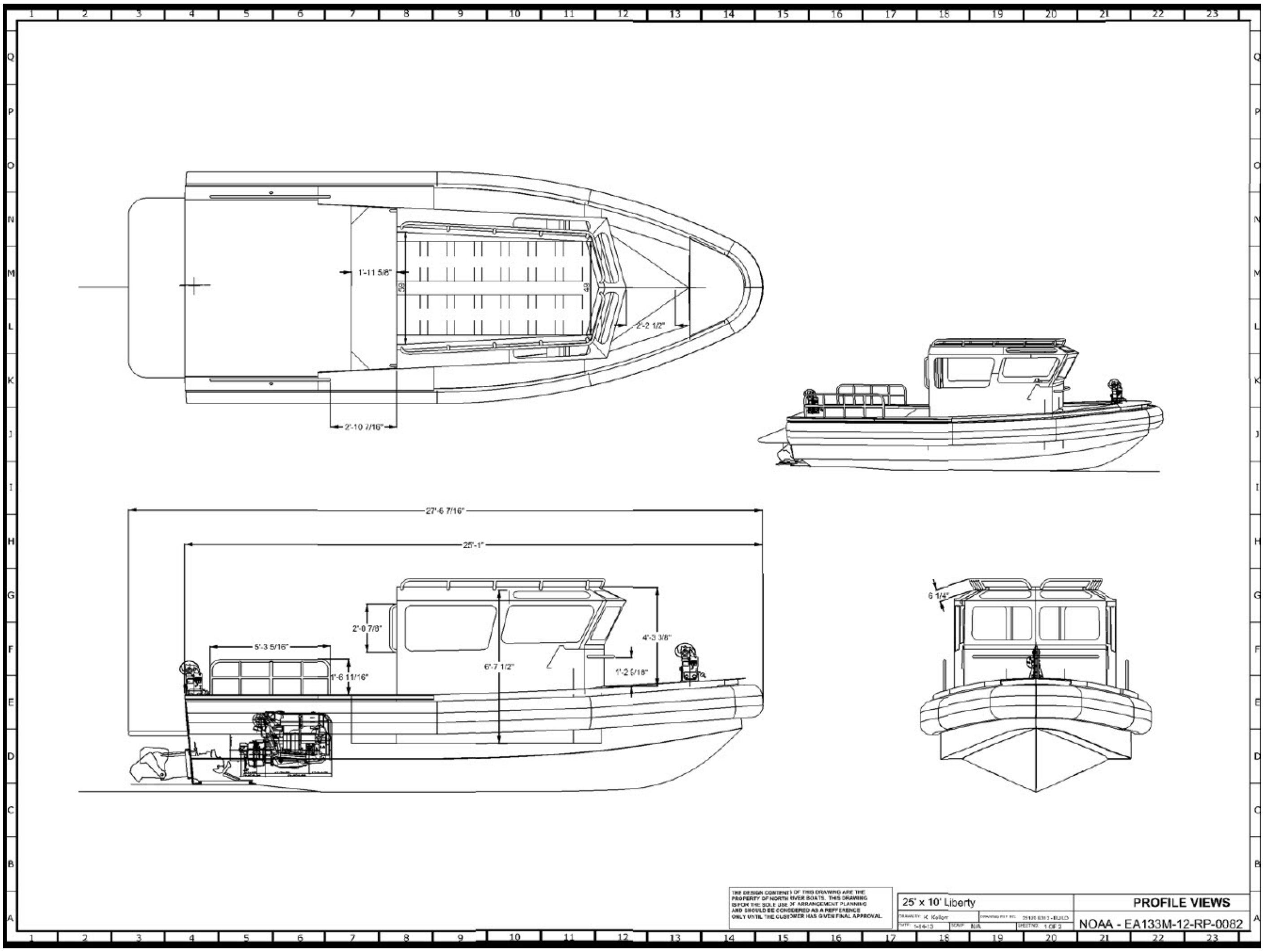
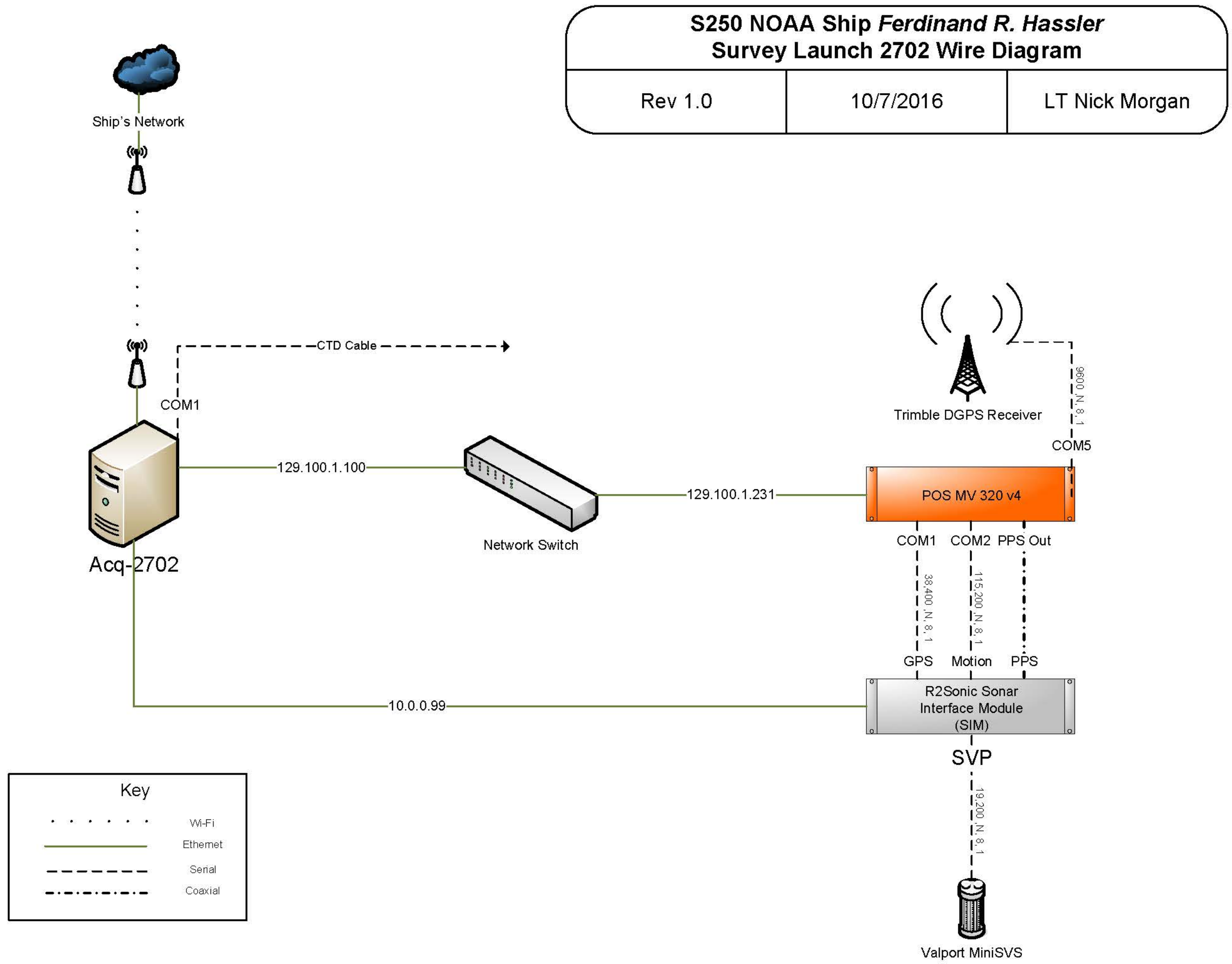


Figure 3: Launch 2702 profiles



A.2 Echo Sounding Equipment

A.2.1 Side Scan Sonars

A.2.1.1 Klein 5000 V2 Bathymetry

Manufacturer	Klein
Model	5000 V2 Bathymetry
Description	High-speed high-resolution towed side-scan sonar (SSS) system. This system is a beamforming acoustic imagery device with an operating frequency of 455 kHz and vertical beam width of 40°. The Klein 5000 V2 system consists of a 5250 V2 towfish and a 5105

<table>
<tr><td></td><td>V2 Transceiver Processing Unit (TPU). The towfish is towed via 3/8" armored coaxial cable connected to a DT marine electro-hydraulic winch (s/n 1271 302 OEHLW3R) equipped with a Klein slip ring model: (14103033, s/n 1802003). The towfish is fitted with a Klein K-wing depressor wing. The winch is controllable from the sonar operator's station. Cable out is measured with a 3PS cable counter integrated with a General Oceanics model 4042 sheave. The sheave is mounted on the A-frame and is the tow point for offsets measurements. Cable counter accuracy was verified on August 3, 2012 using a known length of line.

The SSS cable was re-terminated on July 27, 2012 and a new 12 meter cable mark for the docked and zero measurement was marked and verified on March 3, 2014.

A side scan calibration was conducted on March 8, 2016(Dn068) on a buoy block offshore of Duck, NC with towfish SN: 386. In this test a number of lines were run adjacent to known buoy block. The side scan positions are compared with the multibeam positions in the attached report. The 95% confidence interval of the positioning error is 10.0 meters. The calculated error in the report is within the positioning error threshold established in the 2014 Field Procedures Manual.</td></tr>
<tr><td>Serial Numbers</td><td>
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<tr><td>Vessel Installed On</td><td>S250</td></tr>
<tr><td>TPU s/n</td><td>777</td></tr>
<tr><td>Towfish s/n</td><td>386</td></tr>
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<tr><td>Specifications</td><td>
<table>
<tr><td>Frequency</td><td>455 kilohertz</td></tr>
<tr><td>Along Track Resolution</td><td>
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<tr><td>Resolution</td><td>10 centimeters</td><td>20 centimeters</td><td>36 centimeters</td><td>61 centimeters</td></tr>
<tr><td>Min Range</td><td>38 meters</td><td>75 meters</td><td>150 meters</td><td>250 meters</td></tr>
<tr><td>Max Range</td><td>meters</td><td>meters</td><td>meters</td><td>meters</td></tr>
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<tr><td>Across Track Resolution</td><td>3.75 centimeters</td></tr>
<tr><td>Max Range Scale</td><td>250 meters</td></tr>
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</td></tr>
<tr><td>Manufacturer Calibrations</td><td>
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<tr><td>Vessel Installed On</td><td>S250</td></tr>
<tr><td>Calibration Date</td><td>2016-03-08</td></tr>
</table>
</td></tr>
</table>

Figure 4: Klien 5000 V2 configured for towing

A.2.2 Multibeam Echosounders

A.2.2.1 RESON 7125

Manufacturer	RESON
Model	7125
Description	The RESON 7125 is a dual head, dual frequency system configured to work as a unit. While the particulars of the port system are specified in this section and the starboard head in the following section, this description and following quality control address the two heads as an integrated system.

The port and starboard sonars are mounted in their respective hulls with a 4.5 degree outboard tilt. The sonars can be operated independently, but are typically operated together as a dual-head system using frequency modulated (FM) pulses combined with center frequency separation to enable simultaneous pinging between the heads. When operated as a dual head system, the starboard system acts as the master and the port system the slave. The range scale, ping rate, surface sound speed, and time varied gain (TVG) parameters are controlled by the master.

Patch Tests -

Due to installation of two new receivers during the 2016 April-June drydock period, a new patch test for the Starboard 400kHz and 200kHz modes was conducted on July 9, 2016 (Dn191) in the southern approaches of Rhode Island Sound.

Reference Surfaces -

In conjunction with the new patch test noted above, a reference surface for both Port and Starboard, in both 400kHz and 200kHz modes was conducted on July 11, 2016 (Dn193) in the southern approaches of Rhode Island Sound.

Serial Numbers	*Vessel Installed On*	S250	same
	Processor s/n	18210412051	same
	Transceiver s/n	212036	same
	Transducer s/n	n/a	n/a
	Receiver s/n	0214074	same
	Projector 1 s/n	2611093	same
	Projector 2 s/n	n/a	n/a

Specifications	*Frequency*	400 kilohertz		200 kilohertz	
	Beamwidth	*Along Track*	1.0 degrees	*Along Track*	2 degrees
		Across Track	0.5 degrees	*Across Track*	1 degrees
	Max Ping Rate	50 hertz		50 hertz	
	Beam Spacing	*Beam Spacing Mode*	Equidistant	*Beam Spacing Mode*	Equidistant
		Number of Beams	512	*Number of Beams*	512
	Max Swath Width	140 degrees		140 degrees	
	Depth Resolution	6 millimeters		6 millimeters	
	Depth Rating	*Manufacturer Specified*	150 meters	*Manufacturer Specified*	400 meters
		Ship Usage	100 meters	*Ship Usage*	250 meters

Manufacturer Calibrations	Manufacturer calibration was not performed.

System Accuracy Tests	*Vessel Installed On*	S250	S250
	Methods	Reference surface comparison	Ellipsoidal Referenced Lead Line and Water Line
	Results	Reference surfaces were performed in the vicinity of Rhode Island Sound on July 9, 2016 (DN191). The 7125 200kHz and 400kHz sonars were operated in single head FM and differenced with the opposite side sonar of the same frequency. The distribution of depth differences, port minus starboard 400kHz for DN191 reference surface. Depths from starboard are on average -0.04 meters deeper than depths from port system with a standard deviation of -0.05 meters.	On March 5, 2014 a static lead line comparison was performed relative to the ellipsoid for the port 7125 system. Ellipsoid height was obtained on a fixed mark ashore using static GPS observations. While the ship was pierside at Judd Gregg Marine Research Complex, a lead-line was lowered to the sea floor in the port 7125 field of view while logging sounding data. Observed ellipsoid height was transferred to the suspended lead-line using differential leveling, and the distance from the lead to the mark measured with a steel survey tape. Logged sonar data was processed through CARIS using standard ERS methods to yield an ellipsoid referenced measurement. Results of this test show the sonar measured depth to be 0.03 meters shallower than the lead-line derived depths with a propagated uncertainty of 0.03 meters. In addition to the ellipsoid measurement, the lead-line was marked at the waterline and the distance from the lead to the mark measured with a steel survey tape. Logged sonar data was processed through CARIS using a zero-tide file to yield a waterline referenced measurement. Sonar depths were an average of 0.04 meters deeper than lead-line derived depths with a propagated error of 0.06 meters. The uncertainty of the measurement is dominated by the uncertainty in reading ship draft marks. This test was repeated for the starboard 7125 system. Results show the sonar depth 0.01 meters deeper than the lead-line derived depths with a propagated uncertainty of 0.03 meters. For the waterline; sonar measured depths were an average of 0.15 meters shallower than the lead-line derived depths with a propagated error of 0.06 meters. There is still uncertainty of the measurement, mainly dominated by the uncertainty in reading ship draft marks.

Snippets	Sonar has snippets logging capability.

Figure 5: 7125 Housing flush-mounted on hull.

Figure 6: Location of the patch test and reference surface performed in Rhode Island Sound.

Figure 7: A difference surface showing the difference in the Port 400kHz and Stbd 400kHz systems.

Figure 8: Statistics derived from the difference surface between the Port 400kHz and Stbd 400kHz systems.

A.2.2.2 RESON 7125

Manufacturer	RESON
Model	7125
Description	Starboard system of a dual head configuration. For a description of this system and associated quality control tests, see entry for port 7125.

Serial Numbers	*Vessel Installed On*	S250		same	
	Processor s/n	18215011048		same	
	Transceiver s/n	212035		same	
	Transducer s/n	n/a		n/a	
	Receiver s/n	1215068		same	
	Projector 1 s/n	1111236		same	
	Projector 2 s/n	n/a		n/a	
Specifications	*Frequency*	400 kilohertz		200 kilohertz	
	Beamwidth	*Along Track*	0.5 degrees	*Along Track*	2 degrees
		Across Track	1 degrees	*Across Track*	1 degrees
	Max Ping Rate	50 hertz		50 hertz	
	Beam Spacing	*Beam Spacing Mode*	Equidistant	*Beam Spacing Mode*	Equidistant
		Number of Beams	512	*Number of Beams*	512
	Max Swath Width	140 degrees		140 degrees	
	Depth Resolution	6 millimeters		6 millimeters	
	Depth Rating	*Manufacturer Specified*	150 meters	*Manufacturer Specified*	400 meters
		Ship Usage	100 meters	*Ship Usage*	250 meters
Manufacturer Calibrations	Manufacturer calibration was not performed.				
System Accuracy Tests	System accuracy test was not performed.				
Snippets	Sonar has snippets logging capability.				

A.2.2.3 R2Sonic 2022

Manufacturer	R2Sonic
Model	2022
Description	The Sonic MBES works on a user selectable frequency range of 200 kHz to 400 kHz so it is adaptable to a wide range of survey depths and conditions. The user can adjust the operating frequency, via the Sonic Control GUI, on the fly, without having to shut down the sonar system or change hardware or halt recording data. The Sonic MBES have a user selectable sector angle, from 10° to 160°, using all 256 beams; the desired sector angle can be selected on the fly without a halt to data recording.

	The selected swath angle can also be rotated port or starboard, whilst recording, to direct the highly concentrated beams towards the desired target.				
Serial Numbers	*Vessel Installed On*	2702			
	Processor s/n	103297			
	Transceiver s/n	N/A			
	Transducer s/n	800148			
	Receiver s/n	N/A			
	Projector 1 s/n	N/A			
	Projector 2 s/n	N/A			
Specifications	*Frequency*	200 kilohertz		400 hertz	
	Beamwidth	*Along Track*	1.0 degrees	*Along Track*	2.0 degrees
		Across Track	1.0 degrees	*Across Track*	2.0 degrees
	Max Ping Rate	60 hertz		60 hertz	
	Beam Spacing	*Beam Spacing Mode*	Equidistant	*Beam Spacing Mode*	Equidistant
		Number of Beams	256	*Number of Beams*	256
	Max Swath Width	160 degrees		160 degrees	
	Depth Resolution	12.5 millimeters		12.5 millimeters	
	Depth Rating	*Manufacturer Specified*	100 meters	*Manufacturer Specified*	100 meters
		Ship Usage	100 meters	*Ship Usage*	100 meters
Manufacturer Calibrations	*Vessel Installed On*	2702			
	Calibration Date	2015-11-16			
System Accuracy Tests	*Vessel Installed On*	2702			
	Methods	Reference Surface			
	Results	Reference surfaces were performed in the vicinity of Cape Henry VA in Anchorage B on March 17, 2016 (DN077). The 7125 400kHz sonars were operated in dual head FM mode and compared to Launch 2702's R2Sonic. Results are shown in the text and images below. The distribution of depth differences (Launch 2702's R2Sonic 2022 minus S250's Dual Reson 7125's): Depths from the R2sonic are on average 0.055 meters shallower than depths from the Dual Reson 7125 system with a standard deviation of 0.037 meters.			
Snippets	Sonar has snippets logging capability.				

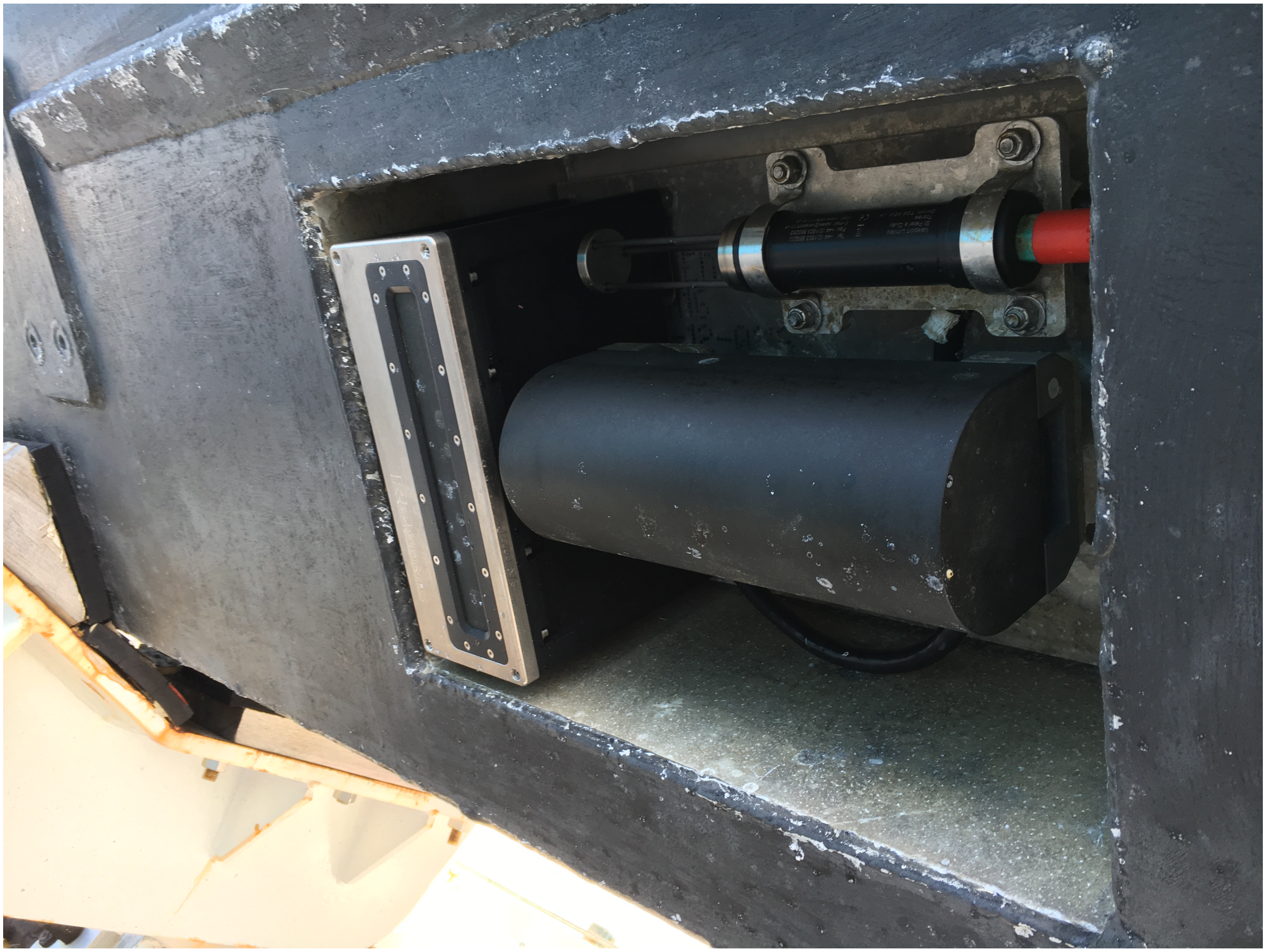

Figure 9: R2Sonic 2022 flush-mounted on hull.

A.2.3 Single Beam Echosounders

No single beam echosounders were utilized for data acquisition.

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

A.3 Manual Sounding Equipment

A.3.1 Diver Depth Gauges

Manufacturer	In-Situ Inc.
Model	Rugged TROLL 100 / Rugged BaroTROLL
Description	The Rugged TROLL 100 is a non-vented (absolute) data logger that measures and records changes in water level, pressure, and temperature. When post-processed with an accompanying CTD cast and tide value, accurate least depths on submerged objects can be obtained. The Rugged BaroTROLL is a data logger used to measure and record barometric pressure, which is used to compensate for changes in water level due to barometric fluctuations. Typically the BaroTROLL is not used for dive operations but may prove to be beneficial for least depth investigations in the future.
Serial Numbers	349000 - Rugged TROLL 100 349047 - Rugged BaroTROLL
Calibrations	No calibrations were performed.
Accuracy Checks	*Serial Number*: 349000 *Date*: 2014-04-15 *Procedures*: Sounding System Comparison - The DLDG was taped to the leadline while recording and submerged to the seafloor for a measurement. A cast was taken during the comparison and the data gathered were processed using Velocipy. The DLDG results were 0.13 meters deeper than the leadline measurement, 0.13 and 0.23 meters shallower than the port and starboard 7125 values, respectively.
Correctors	Correctors were not determined.
Non-Standard Procedures	Non-standard procedures were not utilized.

A.3.2 Lead Lines

Manufacturer	Unknown
Model	Traditional
Description	FERDINAND R. HASSLER is equipped with one lead line. Lead lines are used for measurements near shore over submerged shoals and for echosounder depth comparisons.
Serial Numbers	RA6S
Calibrations	No calibrations were performed.
Accuracy Checks	*Serial Number*: RA6S *Date*: 2016-03-13 *Procedures*: The wet lead line was stretched with an amount of force equal to the weight, on relatively flat ground and compared with a steel survey tape. Values were recorded of true measurements at lead line markings.
Correctors	From the table of values obtained during the accuracy checks a table of correctors was calculated. This table is stored locally aboard the FERDINAND R. HASSLER and referenced when appropriate.
Non-Standard Procedures	Non-standard procedures were not utilized.

Figure 10: Leadline fitted with custom mud-shoe to limit penetration of soft bottoms.

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

<table>
<tr><td>Manufacturer</td><td>Applanix</td></tr>
<tr><td>Model</td><td>POS/MV 320 V5</td></tr>
<tr><td>Description</td><td>Tightly coupled GPS and inertial positioning and attitude sensing system for port hull. Inertial motion unit (IMU) is located below water line close to the port side 7125 wet end. GPS antennae are located on flying bridge of S250. The V5 system was installed on July 29, 2013.</td></tr>
<tr><td>PCS</td><td>
<table>
<tr><td>Manufacturer</td><td>Applanix</td></tr>
<tr><td>Model</td><td>POS/MV 320 V5</td></tr>
<tr><td>Description</td><td>Rack mounted POS control system located in charting lab.</td></tr>
<tr><td>Firmware Version</td><td>8.15</td></tr>
<tr><td>Software Version</td><td>8.15</td></tr>
<tr><td>Serial Numbers</td><td>
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<tr><td>Vessel Installed On</td><td>S250 Port</td></tr>
<tr><td>PCS s/n</td><td>5806</td></tr>
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</table>
</td></tr>
<tr><td>IMU</td><td>
<table>
<tr><td>Manufacturer</td><td>Applanix</td></tr>
<tr><td>Model</td><td>Type 36</td></tr>
<tr><td>Description</td><td>Inertial measurement system consisting of three orthogonal accelerometers and three orthogonal fiber-optic gyroscopes. Located in port hull near 7125 wet end.</td></tr>
<tr><td>Serial Numbers</td><td>
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<tr><td>IMU s/n</td><td>2423</td></tr>
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<tr><td>Certification Date</td><td>2013-06-26</td></tr>
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<tr><td>Antennas</td><td>
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<tr><td>Manufacturer</td><td>Trimble</td></tr>
<tr><td>Model</td><td>GA830 GNSS/MSS</td></tr>
<tr><td>Description</td><td>GNSS/MSS antennae are used for position input as well as aiding the heading solution. The antennae pair for the port system is the forward and aft pair on the port side. The separation distance between the antennae is approximately 2 meters. These new Trimble GA830 antennas were installed on September 30th, 2015.</td></tr>
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<tr><td>S250 Port (forward)</td><td>6997</td><td>Port</td><td>Primary</td></tr>
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<tr><td>Manufacturer</td><td>Applanix</td></tr>
<tr><td>Model</td><td>POS/MV 320 V5</td></tr>
<tr><td>Description</td><td>Tightly coupled GPS and inertial positioning and attitude sensing system for starboard hull. Inertial motion unit (IMU) is located below water line close to the starboard side 7125 wet end. GPS antennae are located on flying bridge of S250. The V5 system was installed on July 29, 2013.</td></tr>
<tr><td>PCS</td><td><table>
<tr><td>Manufacturer</td><td>Applanix</td></tr>
<tr><td>Model</td><td>POS/MV 320 V5</td></tr>
<tr><td>Description</td><td>Rack mounted POS control system located in charting lab.</td></tr>
<tr><td>Firmware Version</td><td>8.15</td></tr>
<tr><td>Software Version</td><td>8.15</td></tr>
<tr><td>Serial Numbers</td><td><table><tr><td>Vessel Installed On</td><td>S250 Starboard</td></tr><tr><td>PCS s/n</td><td>5807</td></tr></table></td></tr>
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<tr><td>Manufacturer</td><td>Applanix</td></tr>
<tr><td>Model</td><td>Type 36</td></tr>
<tr><td>Description</td><td>Inertial measurement system consisting of three orthogonal accelerometers and three orthogonal fiber-optic gyroscopes. Located in starboard hull near 7125 wet end.</td></tr>
<tr><td>Serial Numbers</td><td><table><tr><td>Vessel Installed On</td><td>S250 Starboard hull</td><td>S250 Starboard hull new top hat</td></tr><tr><td>IMU s/n</td><td>2424</td><td>2672</td></tr></table></td></tr>
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<tr><td>Antennas</td><td><table><tr><td>Manufacturer</td><td>Trimble</td></tr></table></td></tr>
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<table>
<tr><td></td><td>
<table>
<tr><td>Model</td><td>GA830 GNSS/MSS</td></tr>
<tr><td>Description</td><td>GNSS/MSS antennae are used for position input as well as aiding the heading solution. The antennae pair for the port system is the forward and aft pair on the port side. The separation distance between the antennae is approximately 2 meters. These new Trimble GA830 antennas were installed on, September 30th, 2015.</td></tr>
<tr><td>Serial Numbers</td><td>
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<tr><td>Vessel Installed On</td><td>Antenna s/n</td><td>Port or Starboard</td><td>Primary or Secondary</td></tr>
<tr><td>S250 Starboard (forward)</td><td>7000</td><td>Starboard</td><td>Primary</td></tr>
<tr><td>S250 Starboard (aft)</td><td>5415</td><td>Starboard</td><td>Secondary</td></tr>
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<tr><td>GAMS Calibration</td><td>
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<tr><td>Vessel</td><td>S250</td></tr>
<tr><td>Calibration Date</td><td>2016-02-11</td></tr>
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<tr><td>Configuration Reports</td><td>POS/MV configuration reports were not produced.</td></tr>
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<table>
<tr><td>Manufacturer</td><td>Applanix</td></tr>
<tr><td>Model</td><td>POS MV 320 v4</td></tr>
<tr><td>Description</td><td>Tightly coupled GPS and inertial positioning and attitude sensing system for launch 2702. Inertial motion unit (IMU) is located underneath the false floor in the bilge compartment next to the coxswain station. GPS antennae are located on cabin-top of 2702.</td></tr>
<tr><td>PCS</td><td>
<table>
<tr><td>Manufacturer</td><td>Applanix</td></tr>
<tr><td>Model</td><td>MV 320 v4</td></tr>
<tr><td>Description</td><td>The POS Computer System (PCS) comprises the processor, GPS receivers and interface cards necessary to communicate with and process the IMU and GPS data. Rack mounted system located in the survey rack underneath the survey station counter in launch 2702.</td></tr>
<tr><td>Firmware Version</td><td>5.03</td></tr>
<tr><td>Software Version</td><td>5.8</td></tr>
<tr><td>Serial Numbers</td><td>
<table>
<tr><td>Vessel Installed On</td><td>2702</td></tr>
<tr><td>PCS s/n</td><td>3189</td></tr>
</table>
</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td rowspan="5">IMU</td><td>Manufacturer</td><td>Applanix</td></tr>
<tr><td>Model</td><td>Type 2</td></tr>
<tr><td>Description</td><td></td></tr>
<tr><td>Serial Numbers</td><td><table><tr><td>Vessel Installed On</td><td>2702</td></tr><tr><td>IMU s/n</td><td>803</td></tr></table></td></tr>
<tr><td>Certification</td><td>IMU certification report was not produced.</td></tr>
<tr><td rowspan="4">Antennas</td><td>Manufacturer</td><td>Trimble</td></tr>
<tr><td>Model</td><td>382AP GNSS</td></tr>
<tr><td>Description</td><td>GNSS antennae are used for position input as well as aiding the heading solution. The antennae pair for the POS MV are located forward and aft on the starboard side. The separation distance between the antennae is approximately 2 meters.</td></tr>
<tr><td>Serial Numbers</td><td><table><tr><td>Vessel Installed On</td><td>Antenna s/n</td><td>Port or Starboard</td><td>Primary or Secondary</td></tr><tr><td>2702 Starboard (aft)</td><td>60243869</td><td>Starboard</td><td>Primary</td></tr><tr><td>2702 Port (fwd)</td><td>60243047</td><td>Port</td><td>Secondary</td></tr></table></td></tr>
<tr><td rowspan="2">GAMS Calibration</td><td>Vessel</td><td>2702</td></tr>
<tr><td>Calibration Date</td><td>2016-03-03</td></tr>
<tr><td>Configuration Reports</td><td colspan="2">POS/MV configuration reports were not produced.</td></tr>
</table>

A.4.2 DGPS

<table>
<tr><td>Description</td><td colspan="2">Hemisphere PGS MBX Kit</td></tr>
<tr><td rowspan="4">Antennas</td><td>Manufacturer</td><td>Hemisphere</td></tr>
<tr><td>Model</td><td>MBX-4</td></tr>
<tr><td>Description</td><td></td></tr>
<tr><td>Serial Numbers</td><td><table><tr><td>Vessel Installed On</td><td>S250</td></tr><tr><td>Antenna s/n</td><td>1113139440044</td></tr></table></td></tr>
</table>

<table>
<tr><td rowspan="5">Receivers</td><td>Manufacturer</td><td colspan="2">Hemisphere</td></tr>
<tr><td>Model</td><td colspan="2">MBX-4</td></tr>
<tr><td>Description</td><td colspan="2"></td></tr>
<tr><td>Firmware Version</td><td colspan="2">1.0</td></tr>
<tr><td>Serial Numbers</td><td colspan="2"><table><tr><td>Vessel Installed On</td><td>S250</td></tr><tr><td>Antenna s/n</td><td>1118144550001</td></tr></table></td></tr>
<tr><td>Description</td><td colspan="3">Trimble DGPS Kit</td></tr>
<tr><td rowspan="4">Antennas</td><td>Manufacturer</td><td colspan="2">Trimble</td></tr>
<tr><td>Model</td><td colspan="2">SPS361</td></tr>
<tr><td>Description</td><td colspan="2"></td></tr>
<tr><td>Serial Numbers</td><td colspan="2"><table><tr><td>Vessel Installed On</td><td>2702</td></tr><tr><td>Antenna s/n</td><td>8838</td></tr></table></td></tr>
<tr><td rowspan="5">Receivers</td><td>Manufacturer</td><td colspan="2">Trimble</td></tr>
<tr><td>Model</td><td colspan="2">SPS361</td></tr>
<tr><td>Description</td><td colspan="2">Auxillary DGPS Receiver</td></tr>
<tr><td>Firmware Version</td><td colspan="2">N/A</td></tr>
<tr><td>Serial Numbers</td><td colspan="2"><table><tr><td>Vessel Installed On</td><td>2702</td></tr><tr><td>Antenna s/n</td><td>5449R80011</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

Manufacturer	Laser Technology Inc
Model	TruPulse 360R
Description	Rugged and waterproof laser rangefinder which provides full measurement capabilities of distances, heights and azimuths.
Serial Numbers	2557
DQA Tests	DQA test was not performed.

Figure 11: TruPulse 360R Laser Rangefinder

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 SeaCat 19plus 350 meter and 3500 meter

Manufacturer	Sea-Bird			
Model	SeaCat 19plus 350 meter and 3500 meter			
Description	Internal logging conductivity, temperature, and depth measuring devices.			
Serial Numbers	*Vessel Installed On*	S250	S250	S250
	CTD s/n	19P65591-6918	19P32914-4480	19P36399-4642
Calibrations	*CTD s/n*	6918	4480	4642
	Date	2016-01-22	2016-01-22	2016-01-22
	Procedures	Routine calibration service	Routine calibration service	Routine calibration service

Figure 12: Ferdinand R. Hassler CTD inventory

A.5.1.2 Sound Speed Profilers

A.5.1.2.1 Rolls-Royce Brooke-Ocean MVP200

Manufacturer	Rolls-Royce Brooke-Ocean
Model	MVP200
Description	The cable was outfitted on August 18, 2014. Towfish with AML Micro-CTD sensor SN-8609 was lost at sea on September 10, 2016 after the cable parted while the towfish was in the docked position. The ship did not have a known spare on hand and performed manual CTDs for the remainder of the year.

Serial Numbers

Vessel Installed On	S250	S250
Sound Speed Profiler s/n	8609	8615

Calibrations

Sound Speed Profiler s/n	8609	8615
Date	2016-01-14	2013-08-10
Procedures	Routine calibration service	Certificate of Conformity

Figure 13: MVP control station & winch

Figure 14: MVP single sensor free fall fish.

A.5.2 Surface Sound Speed

A.5.2.1 Sea-Bird 45 MicroTSG

Manufacturer	Sea-Bird

Model	45 MicroTSG
Description	Two SBE-45 thermosalinographs are installed to determine the sound velocity of the water at the sonar transducers. This data is used to aid beam steering of the multibeam 7111 sonar system, and as a backup sound speed input available for beam steering of the multibeam 7125 sonar systems. One is located in the starboard engine room, the other in the port. Both units draw sampling water from the main cooling water line of the respective main engine. The SBE-45s are configured to use their internal temperature sensors. Both units are insulated with foam to ensure accurate temperature readings. These devices calculate the sound speed from the measured salinity and temperature (using the Chen-Millero equation) of the sampled water. A serial broadcast device sends the sound speed message from the SBE-45 to the RESON 7111 and SCS acquisition server.
Serial Numbers	*Vessel Installed On*: S250 Port / S250 Starboard *Sound Speed Sensor s/n*: 4553332-0276 / 4553332-0277
Calibrations	*Sound Speed Sensor s/n*: 4553332-0276 / 4553332-0277 *Date*: 2015-04-02 / 2015-04-02 *Procedures*: Routine calibration service / Routine calibration service

Serial Numbers

Vessel Installed On	S250 Port	S250 Starboard
Sound Speed Sensor s/n	4553332-0276	4553332-0277

Calibrations

Sound Speed Sensor s/n	4553332-0276	4553332-0277
Date	2015-04-02	2015-04-02
Procedures	Routine calibration service	Routine calibration service

A.5.2.2 RESON SVP-70

Manufacturer	RESON
Model	SVP-70
Description	Sound velocity probe developed for fixed-mount installation near RESON 7125 transducer heads which uses a direct path echosounding technique that instantly compensates for temperature and pressure with internal sensors, providing accurate surface sound velocity measurements for beam steering. During the April-June 2016 drydock period, the port SVP-70 (S/N 2011276) was reinstalled. In August of 2016, the starboard SVP-70 sensor (S/N 2011278) began malfunctioning. The port SVP-70 was then fed to the starboard RESON 7125. The STBD SVP-70 was removed from the hull in December 2016 and sent to the manufacturer for repair.

Serial Numbers

Vessel Installed On	S250 Starboard hull	S250 Port hull
Sound Speed Sensor s/n	2011278	2011276

Calibrations

Sound Speed Sensor s/n	2011278	2011276
Date	2014-03-12	2015-03-24
Procedures	Routine calibration service	Routine calibration service

A.5.2.3 Valeport miniSVS

Manufacturer	Valeport
Model	miniSVS
Description	The miniSVS consists of a single circuit board controlling all sampling, processing and communications functions, and a sensor comprising a ceramic transducer, a signal reflector, and spacer rods to control the path length. The two are connected by a single coaxial cable. A titanium housing may be fitted, which provides waterproof protection to a depth in excess of 6000m.
Serial Numbers	*Vessel Installed On*: 2702 *Sound Speed Sensor s/n*: 48002
Calibrations	*Sound Speed Sensor s/n*: 48002 *Date*: 2016-01-21 *Procedures*: Routine calibration service

Additional Discussion

When in the deployed and docked position, the MVP sensor is towed at approximately the same height as the surface sound speed sensor. As part of the system start up and watch turnover procedures as well as periodically through a survey watch, these values are verified to be in agreement. Comparison casts between a SeaCat 19+ and the MVP are conducted once a project or if any issues with the MVP sensor are suspected. The results of these tests are included in the Separates section of each survey.

A.6 Horizontal and Vertical Control Equipment

A.6.1 Horizontal Control Equipment

A.6.1.1 Base Station Equipment

Description	Trimble NetR5 receiver used for long-term GPS base observations and correctors.

GPS Antennas	*Manufacturer*	Trimble
	Model	Zephyr Geodetic Model 2
	Description	The Zephyr Geodetic 2 is the antenna component for the NetR5 system which incorporates a large Trimble Stealth™ Ground Plane, which reduces multipath interference using technology similar to that used by Stealth aircraft to hide from radar. The antenna is made with weather-resistant materials and a low profile design, so the antenna can be used for many years of continuous operation on a permanent installation.
	Serial Numbers	1440921338
GPS Receivers	*Manufacturer*	Trimble
	Model	NetR5 GNSS
	Description	The Trimble NetR5 Reference Station is a multi-channel, multi-frequency GNSS receiver designed for use as a stand-alone reference station or as part of a GNSS infrastructure solution.
	Firmware Version	4.03
	Serial Numbers	4934K63376
UHF Antennas	No UHF antennas were installed.	
UHF Radios	No UHF antennas were installed.	
Solar Panels	No solar panels were installed.	
Solar Chargers	No solar chargers were installed.	
DQA Tests	No DQA tests were performed.	

A.6.1.2 Rover Equipment

No rover equipment was utilized for data acquisition.

A.6.2 Vertical Control Equipment

No vertical control equipment was utilized for data acquisition.

A.7 Computer Hardware and Software

A.7.1 Computer Hardware

Manufacturer	Dell
Model	T5500
Description	Processing Computers
Serial Numbers	

Computer s/n	*Operating System*	*Use*
FH-PROC1 Service Tag # GFTQ8V1	Windows 7	Processing
FH-PROC2 Service Tag # GFTR8V1	Windows 7	Processing
FH-PROC3 Service Tag # GFTN8V1	Windows 7	Processing
FH-PROC4 Service Tag # GFTM8V1	Windows 7	Processing

Manufacturer	Dell
Model	Precision Tower 7810
Description	Acquisition Computers
Serial Numbers	

Computer s/n	*Operating System*	*Use*
FH-ACQ3 Service Tag # 84WYV52	Windows 7	Acquisition
FH-ACQ4 Service Tag # 84WXV52	Windows 7	Acquisition

Manufacturer	Cybertron PC
Model	Generic
Description	Processing Computer
Serial Numbers	

Computer s/n	*Operating System*	*Use*
FH-PROC5 Service Tag # FQC-00765	Windows 7	Processing

A.7.2 Computer Software

Manufacturer	CARIS
Software Name	HIPS/SIPS
Version	9.1

Service Pack	N/A
Hotfix	24
Installation Date	2016-05-01
Use	Processing
Description	Data Processing (FH used Caris 9.0.21 for initial processing. Surveys from project OPR-D304-FH-16 were transferred to the TJ for final processing and reporting where 9.1.4 was used)

Manufacturer	CARIS
Software Name	Bathy BASE Editor
Version	4.1
Service Pack	N/A
Hotfix	21
Installation Date	2016-05-01
Use	Processing
Description	Data analysis and feature management

Manufacturer	CARIS
Software Name	Plot Composer
Version	5.3
Service Pack	N/A
Hotfix	N/A
Installation Date	2015-02-18
Use	Processing
Description	Mapping and plotting software

Manufacturer	Applanix
Software Name	POSPac
Version	7.2
Service Pack	N/A
Hotfix	N/A
Installation Date	2016-06-01
Use	Processing
Description	Position and Attitude processing software

Manufacturer	NOAA

Software Name	Pydro
Version	16
Service Pack	N/A
Hotfix	N/A
Installation Date	2016-05-01
Use	Processing
Description	Feature management, correlation, and report generator. Pydro automatically updates throughout the project.

Manufacturer	NOAA
Software Name	Velocipy
Version	16
Service Pack	N/A
Hotfix	N/A
Installation Date	2015-02-16
Use	Processing
Description	Feature management, correlation, and report generator, software update installed for bug fixes and schema changes. Velocipy automatically updates with Pydro throughout the project.

Manufacturer	IVS 3D
Software Name	Fledermaus
Version	7
Service Pack	5
Hotfix	3
Installation Date	2016-04-01
Use	Processing
Description	Data modeling

Manufacturer	Hypack
Software Name	Hypack/Hysweep
Version	2014
Service Pack	0
Hotfix	16
Installation Date	2014-02-18
Use	Acquisition

Description	Data logging

Manufacturer	Applanix
Software Name	POSView
Version	8.46
Service Pack	N/A
Hotfix	N/A
Installation Date	2015-12-14
Use	Acquisition
Description	Positioning

Manufacturer	Synergy
Software Name	Synergy
Version	1.4.14
Service Pack	N/A
Hotfix	N/A
Installation Date	2014-02-17
Use	Acquisition
Description	Shared mouse and keyboard between acquisition systems

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 Ponar Wildco 1728

Manufacturer	Ponar Wildco
Model	1728
Description	Grab sampler triggered by contact with sea floor. A custom mount equipped with camera and light was designed for the acquisition of video of the seafloor.

Figure 15: Ponar grab sampler

Figure 16: Camera with custom mount allowing for high quality video of the seafloor

A.8.1.2 Go Pro Hero 3

Manufacturer	Go Pro
Model	Hero 3
Description	Video camera rigged as a drop camera to function along with grab sampler. The camera contains a 12 MP sensor capable of 1440p at 48fps. This camera supplements the data gathered with the grab sampler, and allows the field unit to provide data from null samples from the sediment sampler.

Figure 17: Go Pro video camera.

B Quality Control

B.1 Data Acquisition

B.1.1 Bathymetry

B.1.1.1 Multibeam Echosounder

Multibeam data on S250 are logged locally on the RESON topside machines in s7k format. Multibeam data are also acquired through Hypack/Hysweep in HSX format for bathymetry, though these files are only used in the event of errors in the s7k file and are otherwise discarded. The HSX format includes sounding solutions, navigation and attitude data. Ship navigation and survey line monitoring are performed with Hypack/Hysweep. The s7k format includes sounding solutions, navigation, attitude, and backscatter snippet data. This record is configured to include the following RESON datagrams: 1003: Position; 1012: Roll, Pitch, Heave; 1013: Heading; 7000: 7k Sonar Settings; 7004: 7k Beam Geometry; 7006: 7k Bathymetric Data; 7008: Bathymetry (For UI Display Only); 7017: Bathymetry (RAW for hydrography); 7027: 7k Generic Watercolumn Data (used for snippets backscatter) and 7503: Remote Control Sonar Settings.

All multibeam sonars are configured in equidistant ("Best Coverage" in newest RESON version) beam steering mode. The opening angle of the 7125 systems is configured based on analysis of coverage, speed, and expected sound speed refraction errors for each survey. This angle typically varies between 120 and 140 degrees. Power, gain, and TVG parameters are typically set for a particular project and changes during acquisition are minimal.

The RESON units are interfaced with the acquisition machines through UDP LAN connections over a dedicated network switch (NetGear ProSafe Gigabit Switch). Position and attitude data is passed from the POS-MV to both the RESON machines and to the acquisition computers through dedicated network switches (NetGear ProSafe Gigabit Switch). There is a dedicated switch for the port and starboard POS systems. Time is passed from the POS to the RESON machines via an RS232 serial connection and a PPS pulse via a coaxial cable with BNC connectors. The starboard POS is interfaced with the starboard 7125 and the 7111, which is located in the starboard hull. The port POS is interfaced to the port 7125. A diagram of this configuration is included with the support files to this report and illustrated in Figure 20.

Data acquired on Launch 2702 is processed by the Sonar Interface Module and delivered to the acqusition machine through a direct ethernet connection and logged using Hypack 2015 in the .HSX and R2Sonic .R2S formats. A swath angle of 120 degrees with the sector rotated 20 degrees to counteract the mounting angle on the hull is used as standard procedure. Bottom sampling is set to equidistant quad which distributes soundings evenly in the x and y directions. Roll stabilization is used and frequency can be adjusted on the fly from 200-400kHz. The sonar has the ability to log TruePix (similar to sidescan with 3D relief), Snippets, and Water Column data.

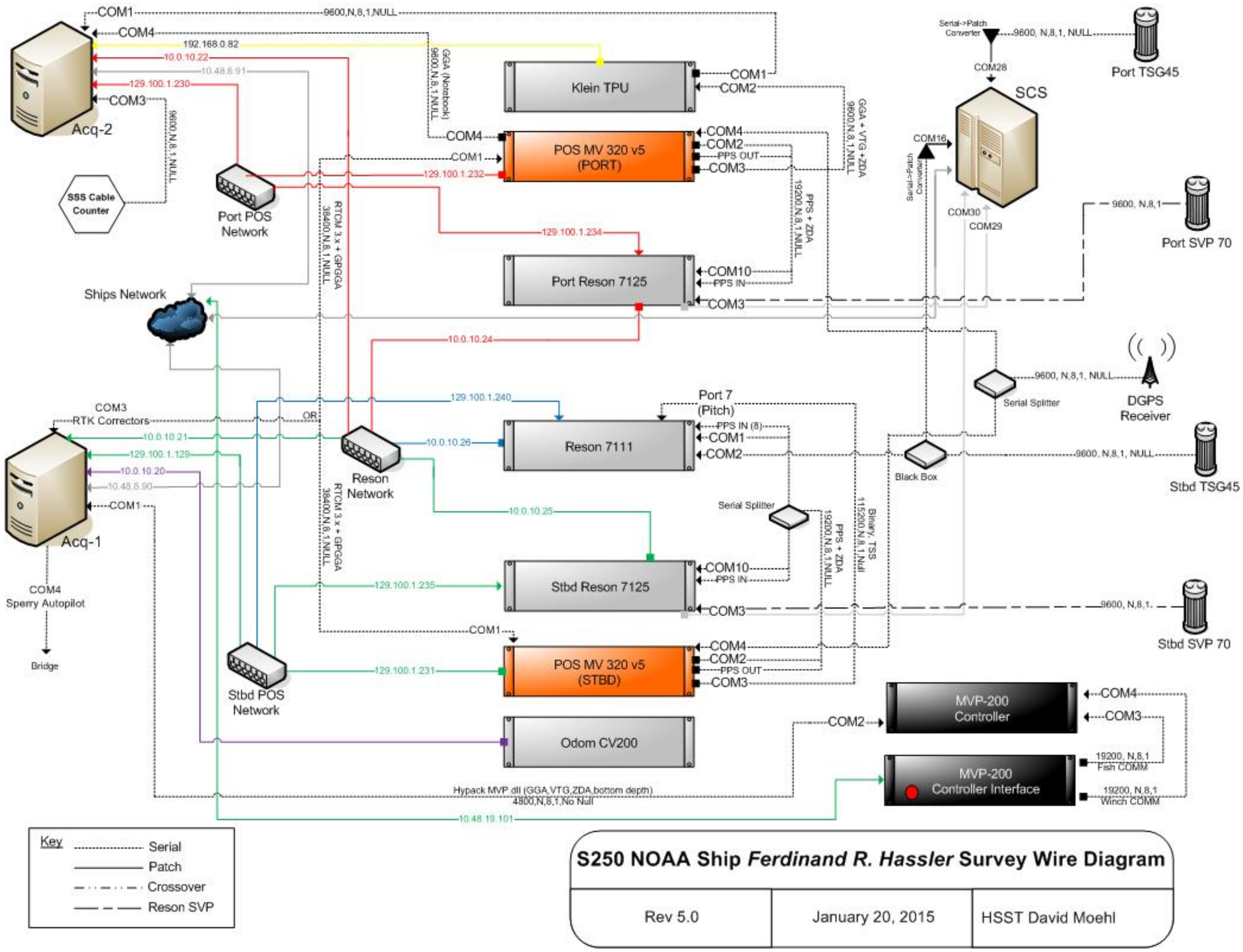


Figure 18: Ship survey systems wiring diagram

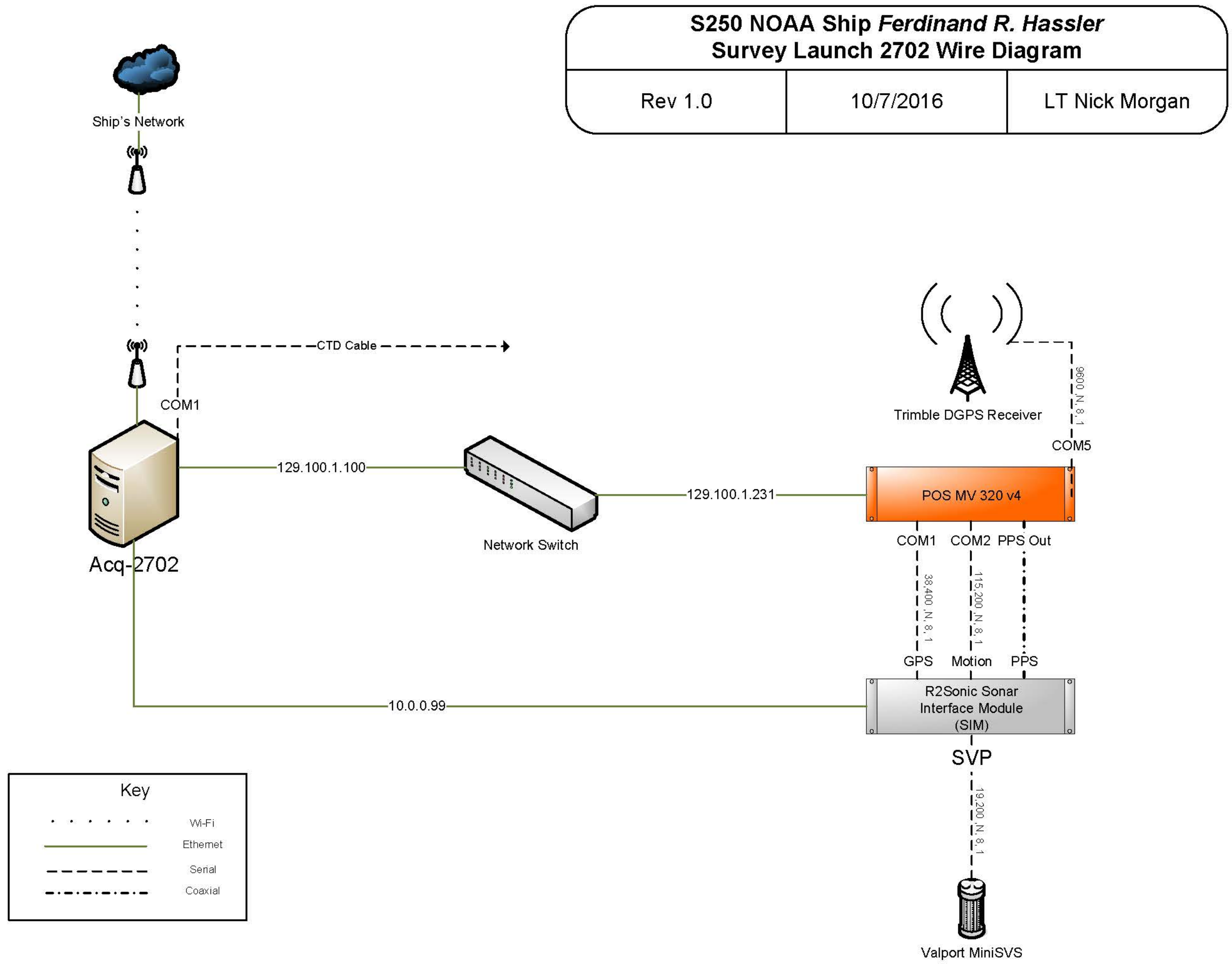


Figure 19: 2702 survey systems wiring diagram

B.1.1.2 Single Beam Echosounder

Single beam echosounder bathymetry was not acquired.

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

Side scan sonar imagery was not acquired.

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

Seabird SBE 19plus and MVP sound speed profilers are used regularly to collect sound speed data for ray tracing corrections for the multibeam sonar systems. The MVP is the primary method of sound speed profiling unless fishing gear or other potential dangers are deemed high enough risk that the MVP could be lost. To mitigate the risk of loss "running" casts are performed, where the ship recovers the MVP immediately upon a successful cast. If it is deemed that a "running" cast is too high risk a "static" cast will be performed, where the ship will stop all way and manually winch out to the desired depth before recovering the towfish. CTD casts are performed if there is not an MVP qualified operator available on watch. Data is retrieved from the Seabird CTDs with a serial connection to a processing computer. Data from both the Seabirds and MVP are processed through the NOAA in-house program Velocipy to give CARIS .svp formatted sound velocity profiles. All .svp profiles for a survey sheet are concatenated to one master file for a survey.

Casts are taken at least every four hours, but typically far more frequently. The interval between casts is typically between ten minutes and four hours based on the observed variability between casts and is discussed in the Descriptive Report of each survey.

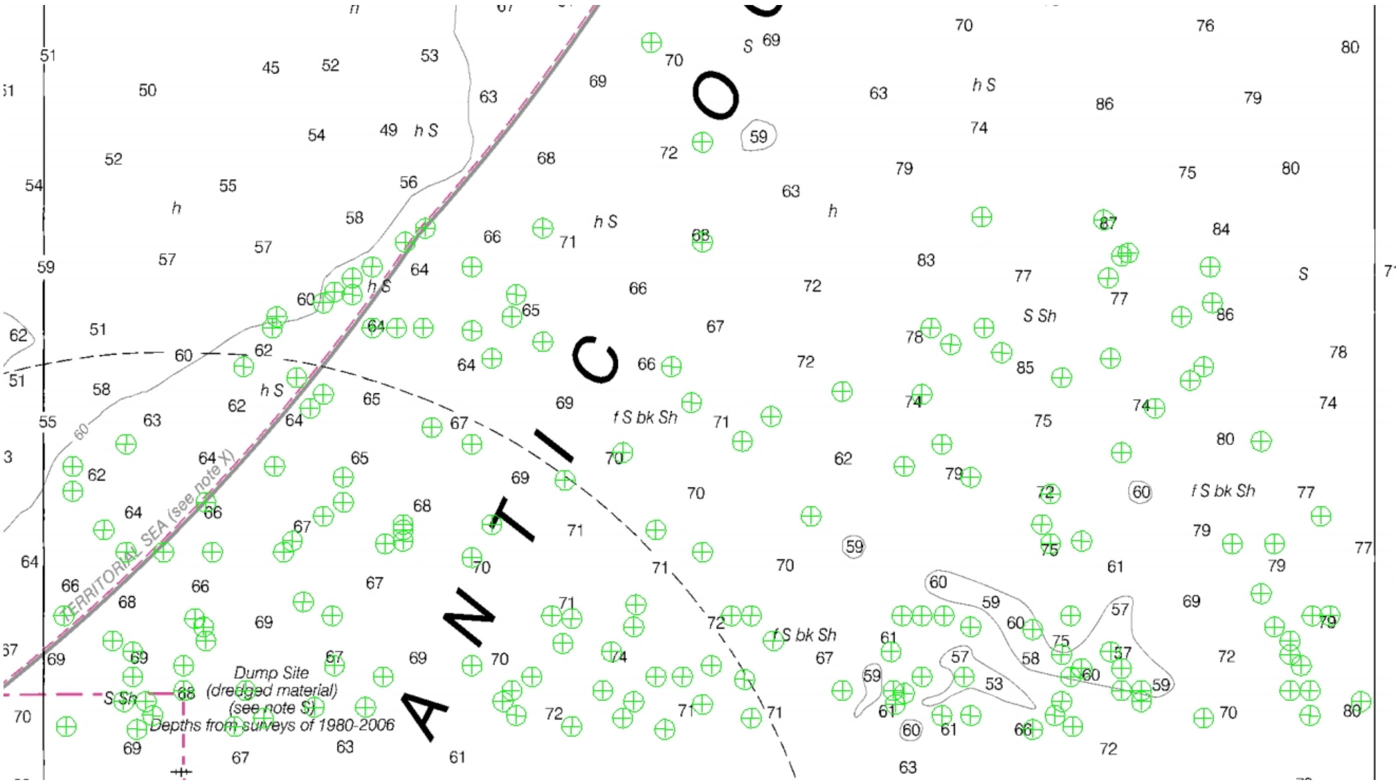


Figure 20: Example of sound speed samples taken in a survey area

B.1.3.2 Surface Sound Speed

Surface sound speed for both RESON 7125 systems is fed from individual SVP-70 sound velocity sensors mounted near each transducer. While operating in dual-head mode the starboard SVP-70 feeds both the master and slave. Seabird TSG 45 thermosalinograph measures sea surface conductivity and temperature and then calculates surface sound speed for the RESON 7111. Surface sound speed is typically compared daily between the real time MVP output and the starboard SVP-70 sensor by the acquisition watch. Data from all surface sound speed sensors can be fed into SCS for real time comparison and are recorded during MVP or CTD casts to perform surface sound speed DQAs.

The R2Sonic 2022 uses a surface sound speed input from the Valeport miniSV that is mounted in the sonar void along with the sonar receiver and transmitter. During regular launch operations, periodic DQAs with the CTDs along with visual comparisons cast to cast by the acquisition operator.

B.1.4 Horizontal and Vertical Control

B.1.4.1 Horizontal Control

Applanix POS/MV files are logged using both the USB logging function and Ethernet logging function. Both files contain the same data records including attitude, heading, position, and velocity data as stated in section 3.4.1 of the FPM. During acquisition, the navigation solution status is constantly monitored by the acquisition watch stander.

The internal (USB) logged files are size limited, therefore files submitted typically start with the .000 extension and increment upwards (e.g. .001, .002, .003, ...). There are approximately 240 files generated during 24 hours of acquisition. The Ethernet logged files are typically broken at approximately UTC noon and midnight each day to yield two files per hull for a survey day.

Real-time USCG DGPS correctors are used for all acquisition. Specific DGPS stations are noted in the DR accompanying each survey.

B.1.4.2 Vertical Control

Preliminary, observed, and verified water levels are downloaded using FetchTides and applied to the data using CARIS HIPS Load Tide function. For data submission, depth data are reduced to MLLW either through application of Verified Water levels and Verified Tidal Zoning or using GPS derived vertical positions and the VDatum model. Refer to individual sheet DRs for detailed methods and additional information.

B.1.5 Feature Verification

Feature verification data were not acquired.

B.1.6 Bottom Sampling

Bottom Sampling followed guidelines set forth in sections 7.1 of the HSSD and 2.5.4.2.1 of the FPM. Unless specified otherwise in the DR, bottom sample locations are guided by analysis of the backscatter and bathymetry of the survey area. Refer to individual sheet DR for additional information.

B.1.7 Backscatter

Backscatter is acquired in the 7008 record logged in the .s7k files directly from the RESON 7125 processors. For the 7125 400kHz systems, snippet size is set to 25 samples in water depths less than 50 meters and to 50 samples in depth greater than 50 meters. The 7125 200kHz system has snippets size set to 100 in depths less than 100 meters and 200 in all depths greater than 100 meters. 7111 snippet size is set to 40 samples in depths less than 80 meters, 80 samples in depths between 150 and 300 meters, and 120 samples in deeper depths. All processing of backscatter is done using the FMGT module of the QPS Fledermaus package.

B.1.8 Other

No additional data were acquired.

Additional Discussion

FERDINAND R. HASSLER maintains a continuous manned survey watch during all survey acquisition. The watch stander is in constant communication with the bridge and monitors the performance of all systems. Thresholds set in Hypack/Hysweep, POSview, RESON, and SonarPro alert the watch stander by displaying alarm messages when error thresholds or tolerances are exceeded. 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, excessive cross track error, or vessel speed approaching the maximum allowable survey speed are addressed by the watch stander and corrected before further data acquisition occurs.

B.2 Data Processing

B.2.1 Bathymetry

B.2.1.1 Multibeam Echosounder

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

Raw .s7k (Reson 7125s) and .HSX/.R2S (R2Sonic 2022) multibeam data were converted to CARIS HIPS HDCS format using established and internally documented settings. After TrueHeave, sound speed, water level correctors, and SBETS are applied to all lines, GPS Tides are calculated using the HSD Operations Branch provided VDatum separation model and the lines are merged. Once lines are merged, Total Propagated Uncertainty (TPU) is computed using settings documented for each survey in the Descriptive Report. Default CARIS device models (devicemodels.xml) are used during processing.

The general resolution, depth ranges, and Combined Uncertainty and Bathymetric Estimator (CUBE) parameter settings outlined in section 5.2.2.2 of the HSSD and section 4.2.1.1.1.1 of the FPM are used for surface creation and analysis. If these depth range values for specific resolutions require adjustment for analysis and submission of individual surveys then the required waiver from NOAA HSD Operations is requested. A detailed listing of the resolutions and the actual depth ranges used during the processing of each survey, along with the corresponding fieldsheet(s), is provided in the Descriptive Report of each survey.

BASE surfaces were created using the CUBE algorithm and parameters contained in the NOAA CUBEParams_NOAA.xml file as provided in Appendix 4 of the FPM. The CUBEParams_NOAA.xml file is included with the HIPS Vessel Files with the individual survey data. The NOAA parameter configurations for resolutions 0.5-16 meters are used.

Multibeam data were reviewed and edited in HIPS Subset Editor as necessary. The finalized BASE surfaces and CUBE hypotheses guided directed data editing at the appropriate depth range in subset editor. The surfaces and subset editor views were also used to demonstrate coverage and to check for errors due to tides, sound speed, attitude and timing.

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

Either the Density or the Density & Locale method for hypothesis disambiguation is typically used. This follows section 4.2.1.1.1 of the FPM as available disambiguation methods. The disambiguation method can be seen in each individual layers properties and can be modified if desired.

The surface filtering function in CARIS HIPS is not utilized routinely. If utilized, the individual Descriptive Report lists the confidence level settings for standard deviation used and discuss the particular way the surface filter was applied.

Designated soundings were selected as outlined in section 5.2.1.2 of the HSSD.

IHO child layers were created using the following two formulas for IHO_1 and IHO_2, respectively; -Uncertainty/((0.5^2 +((Depth*0.013)^2))^0.5) and -Uncertainty/((1.0^2 +((Depth*0.023)^2))^0.5). IHO_1 is created for all soundings less than 100 meters while IHO_2 is for 100 meters and deeper. This layer is then exported and run through an application which computes statistics. The results are reported and analyzed in each sheets' individual DR, but the layers are not submitted with the survey.

Additionally, a combined resolution surface was created and reviewed in 3-D mode using one of the following programs; CARIS HIPS, CARIS Base Editor or IVS Fledermaus, to ensure that the data are sufficiently free of artifacts and is a reasonable model of the sea floor.

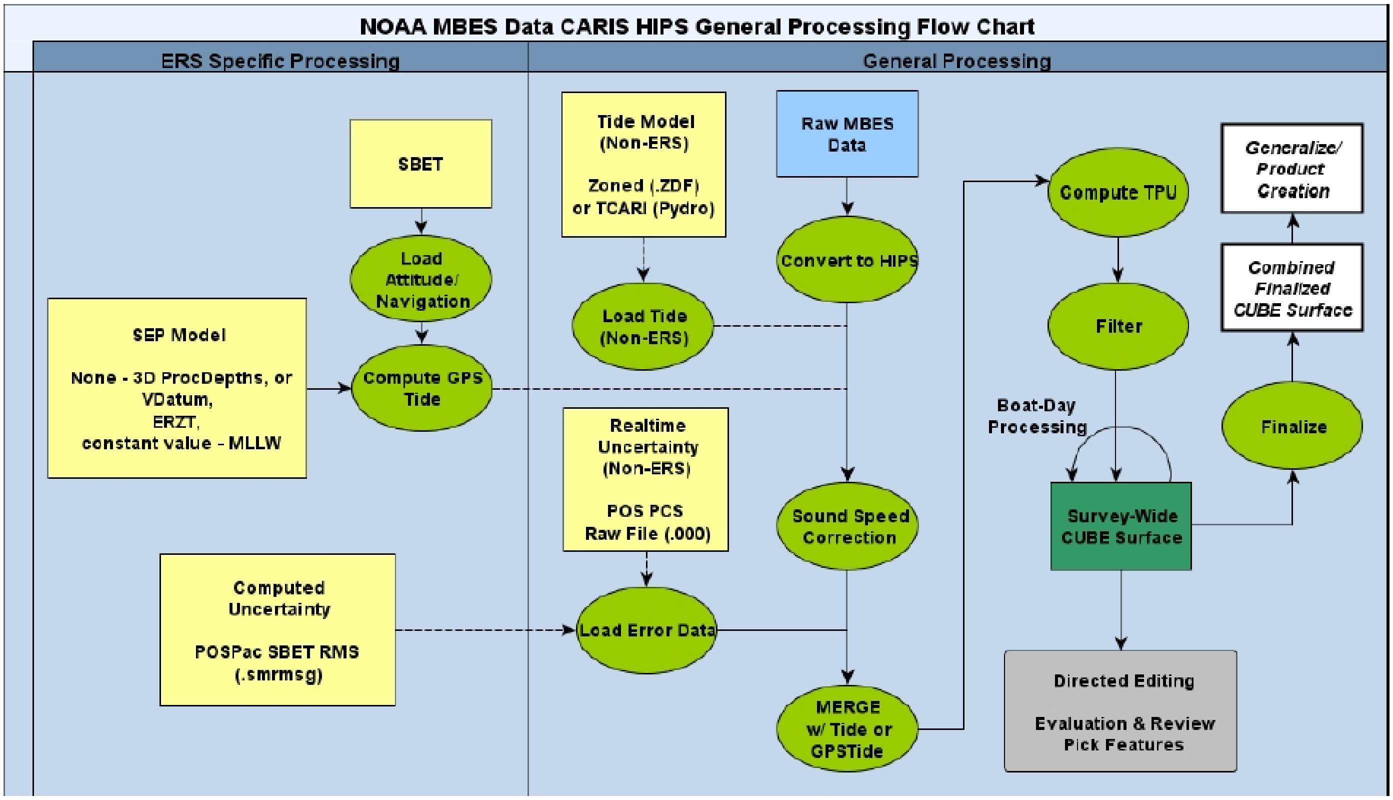


Figure 21: MBES flow diagram

B.2.1.2 Single Beam Echosounder

Single beam echosounder bathymetry was not processed.

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

Quality control logs were used to track and communicate problems during processing.

B.2.1.4.2 Methods Used to Generate Bathymetric Grids

All methods used to generate final bathymetric grids are followed as put forth in section 4.2 and all relevant subsections of the FPM.

B.2.1.4.3 Methods Used to Derive Final Depths

Methods Used	Cleaning Filters Gridding Parameters Surface Computation Algorithms
Description	Filters were used on a case by case basis as determined by the hydrographer, refer to individual sheet DRs for more information.

B.2.2 Imagery

B.2.2.1 Side Scan Sonar

Side scan sonar imagery was not processed.

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

Processing logs were used to record and communicate problems from acquisition to final processing.

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

Range of the SSS, XTE, speed of vessel collecting data, and repetitious processing examinations were all used
to ensure that object detection and accuracy requirements are met.

B.2.2.3.3 Methods Used to Verify Swath Coverage

Swath coverage is verified through construction of side scan mosaics. During acquisition, the outer portions of the swath are monitored for refraction artifacts. If an apparent refraction artifact impacts object detection ability and cannot be eliminated through adjustment of fish height, the range scale is reduced.

B.2.2.3.4 Criteria Used for Contact Selection

In CARIS SIPS, if an apparent shadow measures greater than 1.0 meters a contact is chosen for development by MBES.

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

Daily sound speed profiles from the SBE and MVP profilers were processed with Velocipy after acquisition.

Project OPR-G309-FH-16 Note:
Based on feedback from the Atlantic Hydrographic Branch (AHB), the Ferdinand R. Hassler discovered that one element of the recommended Caris processing workflow was not followed throughout project OPR-G309-FH-16. The Caris Sound Velocity Correction (SVC) process was conducted before but not after loading Smoothed Best Estimates of Trajectory (SBETs). It is recommended to perform the SVC process after loading SBETs in order for the ray tracing to account for the updated motion and attitude information. A copy of survey H12932 was re-processed to assess the effect of not applying SVC after loading SBETs. As viewed in Caris Subset Editor, the vertical difference between processing methods ranged from 0.005 - 0.010 meters in all sampled areas, including two wrecks. The SVC processing methods were also compared using 2 meter and 4 meter difference surfaces. In the 2 meter difference surface, the depths differ by -8.17 to 3.07 meters, with a mean difference of 0.00 meters and a standard deviation of 0.00 meters, and 95% of nodes exhibit a depth difference of ±0.01 meters. In the 4 meter difference surface, the depths differ by -0.74 to 0.62 meters, with a mean difference of 0.00 meters and a standard deviation of 0.00 meters, and 95% of nodes exhibit a depth difference of ±0.01 meters. The high values in the difference surfaces are isolated and limited to features and steep slopes. A detailed review confirmed that the high values in the difference surfaces are entirely the result of CUBE gridding inconsistencies and small horizontal shifts in the grid node structure rather than actual vertical differences in the sounding data. The results of this testing were discussed with HSD Operations and AHB. Based on the limited magnitude of the error, it was concluded that re-processing the entire project was unnecessary. The ship's Caris processing SOP has been updated to reflect the recommended SVC workflow. Details on the analysis can be found in the Appendix.

B.2.3.1.1 Specific Data Processing Methods

B.2.3.1.1.1 Caris SVP File Concatenation Methods

CTD profiles from the Seabird SBE 19-plus and AML Micro-CTD were processed using the NOAA developed program Velocipy. From each system, sound speed profiles are extracted and archived as both individual and concatenated CARIS SVP files.

B.2.3.2 Surface Sound Speed

The SBE-45s were configured to average four samples and report the result once a second. No additional filters are applied.

B.2.4 Horizontal and Vertical Control

B.2.4.1 Horizontal Control

Fixed USCG DGPS stations were used for all real-time horizontal control. If post-processed GPS techniques were used to improve horizontal and vertical control, specific information is included in the Descriptive Report and/or the project's Horizontal and Vertical Control Report.

If USB logged TrueHeave files contained IMU data gaps or other errors apparent during post processing, the Ethernet-logged files may be examined and used if free from gaps. If this is the case both files will be submitted with the GNSS data.

B.2.4.2 Vertical Control

CO-OPS zoned water levels utilizing water level observations from fixed, continuously operating NOAA tide gages are used for reduction of data to MLLW. Predicted water levels are applied during preliminary processing. Before submission, verified water levels are applied to all tidally corrected data. If post-processed GPS techniques are used to improve vertical control, specific information is included in the Descriptive Report and/or the project's Horizontal and Vertical Control Report.

B.2.5 Feature Verification

Features were processed using CARIS BASE Editor software and were included with submitted in the survey's final feature file (FFF) in S-57 .000 format. The FFF includes all features; buoys, rocks, wrecks, bottom samples, etc., addressed within the limits of each individual sheet.

B.2.6 Backscatter

All backscatter was processed from acquired RESON .s7k or Hypack .7k files. All backscatter processing was performed with QPS Fledermaus Geocoder Toolbox and a mosaic calculated with default processing parameters. RESON TVG plugins were used for all processing steps.

B.2.7 Other

No additional data were processed.

B.3 Quality Management

Standard Operating Procedures (SOPs) and checklists are followed by personnel throughout the survey to ensure consistent high quality data and products.

Data are reviewed for artifacts and errors during daily processing, and also reviewed by the Field Operations Officer and/or Hydrographic Senior Survey Technician daily. Before any data is to be submitted it is reviewed independently by at least three experienced hydrographers who are signatories to the Descriptive Report.

B.4 Uncertainty and Error Management

TPU is processed using the following settings.

B.4.1 Total Propagated Uncertainty (TPU)

B.4.1.1 TPU Calculation Methods

TPU is calculated in CARIS HIPS using the Compute TPU tool. Project specific values for tide and sound speed are entered and used over the duration of each project.

B.4.1.2 Source of TPU Values

Error values for the multibeam and positioning systems were compiled from manufacturer specifications sheets for each sensor and from values set forth in section 4.2.3.8 of the 2014 FPM.

B.4.1.3 TPU Values

Vessel	S250 (Port)		
Echosounder	RESON 7125 200 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.020 degrees
		Heave	5 % Amplitude
			0.050 meters
		Pitch	0.020 degrees
		Roll	0.020 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*	0.050 meters	
		y	0.050 meters	
		z	0.050 meters	
	MRU Alignment	*Gyro*	0.100 degrees	
		Pitch	0.020 degrees	
		Roll	0.020 degrees	
	Vessel	*Speed*	0.050 meters/second	
		Loading	0.050 meters	
		Draft	0.050 meters	
		Delta Draft	0.050 meters	
Vessel	S250 (Port)			
Echosounder	RESON 7125 400 kilohertz			
TPU Standard Deviation Values	*Motion*	*Gyro*	0.020 degrees	
		Heave	5.000 % Amplitude	
			0.050 meters	
		Pitch	0.020 degrees	
		Roll	0.020 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*	0.050 meters	
		y	0.050 meters	
		z	0.050 meters	

	MRU Alignment	*Gyro*	0.027 degrees
		Pitch	0.04 degrees
		Roll	0.04 degrees
	Vessel	*Speed*	0.050 meters/second
		Loading	0.050 meters
		Draft	0.050 meters
		Delta Draft	0.050 meters
Vessel	S250 (Starboard)		
Echosounder	RESON 7111 100 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.020 degrees
		Heave	5.000 % Amplitude
			0.050 meters
		Pitch	0.020 degrees
		Roll	0.020 degrees
	Navigation Position	1.000 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*	0.100 meters
		y	0.100 meters
		z	0.100 meters
	MRU Alignment	*Gyro*	0.130 degrees
		Pitch	0.030 degrees
		Roll	0.030 degrees
	Vessel	*Speed*	0.030 meters/second
		Loading	0.040 meters
		Draft	0.050 meters
		Delta Draft	0.050 meters
Vessel	S250 (Starboard)		
Echosounder	RESON 7125 200 kilohertz		

TPU Standard Deviation Values	*Motion*	*Gyro*	0.020 degrees
		Heave	5 % Amplitude
			0.050 meters
		Pitch	0.020 degrees
		Roll	0.020 degrees
	Navigation Position	1.000 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*	0.080 degrees
		Pitch	0.010 degrees
		Roll	0.010 degrees
	Vessel	*Speed*	0.050 meters/second
		Loading	0.050 meters
		Draft	0.050 meters
		Delta Draft	0.050 meters
Vessel	S250 (Starboard)		
Echosounder	RESON 7125 400 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.020 degrees
		Heave	5 % Amplitude
			0.050 meters
		Pitch	0.020 degrees
		Roll	0.020 degrees
	Navigation Position	1.000 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*	0.090 degrees
		Pitch	0.030 degrees
		Roll	0.030 degrees
	Vessel	*Speed*	0.050 meters/second
		Loading	0.050 meters
		Draft	0.050 meters
		Delta Draft	0.050 meters

B.4.2 Deviations

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

Additional Discussion

MRU Align StdDev gyro and MRU Align StdDev Roll/Pitch were derived during patch test processing. Typically several individuals come up with five values for timing, pitch, roll, and yaw. A standard deviation is computed from the different values obtained by each individual. The standard deviation from each individual is then averaged and used as the MRU alignment error (standard deviation of all the independent measurements divided by the square root of the number of measurements).

S250:	MRU Align StdDev gyro	MRU Align StdDev Roll/Pitch
Port 7125 400kHz:	0.070m	0.080m
Port 7125 200kHz:	0.060m	0.060m
Stbd 7125 400kHz:	0.090m	0.060m
Stbd 7125 200kHz:	0.120m	0.020m

2702:

R2Sonic:	0.090m	0.020m

C Corrections To Echo Soundings

C.1 Vessel Offsets and Layback

C.1.1 Vessel Offsets

C.1.1.1 Description of Correctors

No description was provided.

C.1.1.2 Methods and Procedures

Sensor offsets are measured with respect to the vessel's reference point. These offsets are derived from the full survey performed in the shipyard, a partial survey performed by NGS personnel and measurements/ verifications performed by FERDINAND R. HASSLER personnel. All offsets are tracked and updated as needed on a spreadsheet submitted with the appendices of this report.

The port IMU serves as the reference point for the port-only 7125 HSX configuration, the port 7125 s7k configuration and the side scan sonar. For all other vessel configurations the starboard IMU is the reference point.

POS GPS antennae pairs are mounted to a 2 meter length of channel extrusion in a fore and aft orientation.

C.1.1.3 Vessel Offset Correctors

<table>
<tr><td>Vessel</td><td colspan="3">S250 Port</td></tr>
<tr><td>Echosounder</td><td colspan="3">RESON 7125 400 kilohertz</td></tr>
<tr><td>Date</td><td colspan="3">2013-07-01</td></tr>
<tr><td rowspan="6">Offsets</td><td rowspan="6">MRU to Transducer</td><td>x</td><td>-1.244 meters</td></tr>
<tr><td>y</td><td>0.362 meters</td></tr>
<tr><td>z</td><td>1.349 meters</td></tr>
<tr><td>x2</td><td>N/A</td></tr>
<tr><td>y2</td><td>N/A</td></tr>
<tr><td>z2</td><td>N/A</td></tr>
</table>

	Nav to Transducer	*x*	-2.246 meters
		y	-2.351 meters
		z	14.269 meters
		x2	N/A
		y2	N/A
		z2	N/A
	Transducer Roll	*Roll*	4.500 degrees
		Roll2	N/A
Vessel	S250 Port (For use with STBD POS data)		
Echosounder	RESON 7125 400 hertz		
Date	2013-07-01		
Offsets	*MRU to Transducer*	*x*	-13.490 meters
		y	0.338 meters
		z	4.311 meters
		x2	N/A
		y2	N/A
		z2	N/A
	Nav to Transducer	*x*	-10.386 meters
		y	-2.362 meters
		z	46.699 meters
		x2	N/A
		y2	N/A
		z2	N/A
	Transducer Roll	*Roll*	4.5 degrees
		Roll2	N/A
Vessel	S250 Starboard		
Echosounder	RESON 7125 400 kilohertz		
Date	2013-07-01		
Offsets	*MRU to Transducer*	*x*	1.424 meters
		y	0.380 meters
		z	1.358 meters
		x2	N/A
		y2	N/A
		z2	N/A

	Nav to Transducer	*x*	4.528 meters
		y	-2.320 meters
		z	14.278 meters
		x2	N/A
		y2	N/A
		z2	N/A
	Transducer Roll	*Roll*	-4.500 degrees
		Roll2	N/A
Vessel	S250		
Echosounder	RESON 7111 100 kilohertz		
Date	2013-07-01		
Offsets	*MRU to Transducer*	*x*	1.203 meters
		y	11.608 meters
		z	0.977 meters
		x2	N/A
		y2	N/A
		z2	N/A
	Nav to Transducer	*x*	4.307 meters
		y	8.908 meters
		z	13.897 meters
		x2	N/A
		y2	N/A
		z2	N/A
	Transducer Roll	*Roll*	0.000 degrees
		Roll2	0.000 degrees
Vessel	S250		
Echosounder	Odom Echotrac CV200 - Transducer 1 = Starboard hull (200 kHz), Transducer 2 = Port hull (24 kHz) 24 kilohertz		
Date	2013-07-01		
Offsets	*MRU to Transducer*	*x*	-0.455 meters
		y	4.620 meters
		z	1.383 meters
		x2	-12.701 meters
		y2	4.620 meters
		z2	1.381 meters

	Nav to Transducer	*x*	2.649 meters
		y	1.920 meters
		z	14.303 meters
		x2	-9.597 meters
		y2	1.920 meters
		z2	14.301 meters
	Transducer Roll	*Roll*	0.000 degrees
		Roll2	0.000 degrees
Vessel	2702		
Echosounder	R2Sonic 2022 200 kilohertz		
Date	2016-09-11		
Offsets	*MRU to Transducer*	*x*	0.237 meters
		y	-0.833 meters
		z	0.407 meters
		x2	0 meters
		y2	0 meters
		z2	0 meters
	Nav to Transducer	*x*	0.759 meters
		y	-0.309 meters
		z	-2.932 meters
		x2	0 meters
		y2	0 meters
		z2	0 meters
	Transducer Roll	*Roll*	20.000 degrees
		Roll2	N/A

C.1.2 Layback

C.1.2.1 Description of Correctors

Layback is calculated in CARIS from the cable-out and fish depth. Cable-out is output from a cable counter and recorded in the .sdf file. The side scan cable is marked at 12 meters and is deployed to this position on launching. The cable counter is reset to zero at this position and the 12 meter offset applied in SonarPro. Thus, the cable out value in the .sdf file is the correct value for the cable between the tow point and the towfish.

C.1.2.2 Methods and Procedures

No layback correctors are applied in the HVF

C.1.2.3 Layback Correctors

Vessel	S250		
Echosounder	Klein 5250 455 kilohertz		
Date	2013-07-01		
Layback	*Towpoint*	*x*	7.161 meters
		y	-26.032 meters
		z	-9.347 meters
	Layback Error	0.00 meters	

Additional Discussion

C.2 Static and Dynamic Draft

C.2.1 Static Draft

C.2.1.1 Description of Correctors

Because of her SWATH design, FERDINAND R. HASSLER is particularly susceptible to loading and trim. While underway, the ballast is actively managed to maintain the draft at the design draft of 3.77 meters. During typical survey operations, HASSLER burns approximately 4,000 liters of diesel per day. At a density of 0.83 kilograms/liter this is approximately 3.3 metric tons of fuel per day. At design draft of 3.77 meters, 1.3 metric tons is required to submerge an additional 0.01 meters of the hull in salt water. The daily fuel burn would thus account for 0.03 meters of variation in the draft. Ballast is adjusted daily to account for fuel burn and the levels in other tanks. Uncertainty is estimated at 0.05 meters.

C.2.1.2 Methods and Procedures

The waterline to reference point is calculated from the vessel offset survey and the vessel draft marks.

C.2.2 Dynamic Draft

C.2.2.1 Description of Correctors

Dynamic draft is calculated as the dynamic height of the vessel reference point as a function of vessel speed compared to the height at rest. This correction is applied during CARIS processing.

C.2.2.2 Methods and Procedures

An ellipsoidally referenced dynamic draft measurement (ERDDM) was performed on following guidelines in the 2014 FPM on February 21, 2016 (Dn28) for vessel S250. An area was selected about 30NM off the VA/NC coast where the slope of the geoid was minimal. Speeds from 6 to 13 knots were run in one direction. The ship was then turned to the reciprocal heading, brought to a complete stop, and then the speeds from 6 to 13 knots were run in the opposite direction.

The fourth order polynomial results for the dynamic draft curves from the port and starboard side were averaged. The 2016 results and comparisons between 2011 - 2016 can be found included in the attached appendices. Results from the last three years were averaged for use as the dynamic draft corrector values for 2016.

Similar methods were used in performing the ERDDM for launch 2702 which was performed in the York River on March 3, 2016 (Dn063). This was the first ERDDM performed on the vessel, therefore no previous years values were available for averaging. The 2016 results were used for dynamic draft correctors.

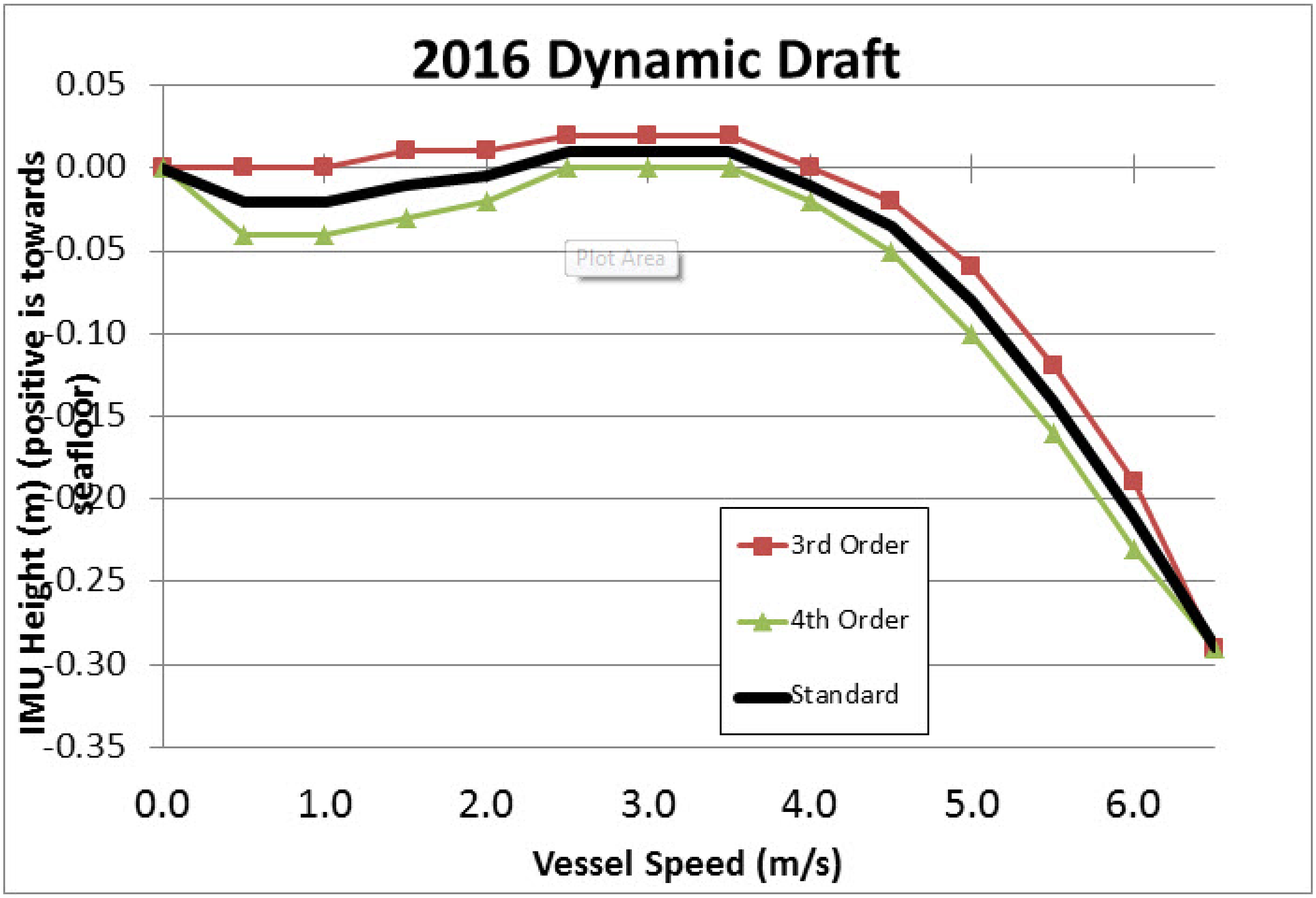


Figure 22: S250 dynamic draft derived from ERDDM methods. Positive values are displacements of the IMU towards the sea floor. Thin lines are results from port and starboard head for third and fourth order polynomial fits. Black bold line is dynamic draft value used for both hulls.

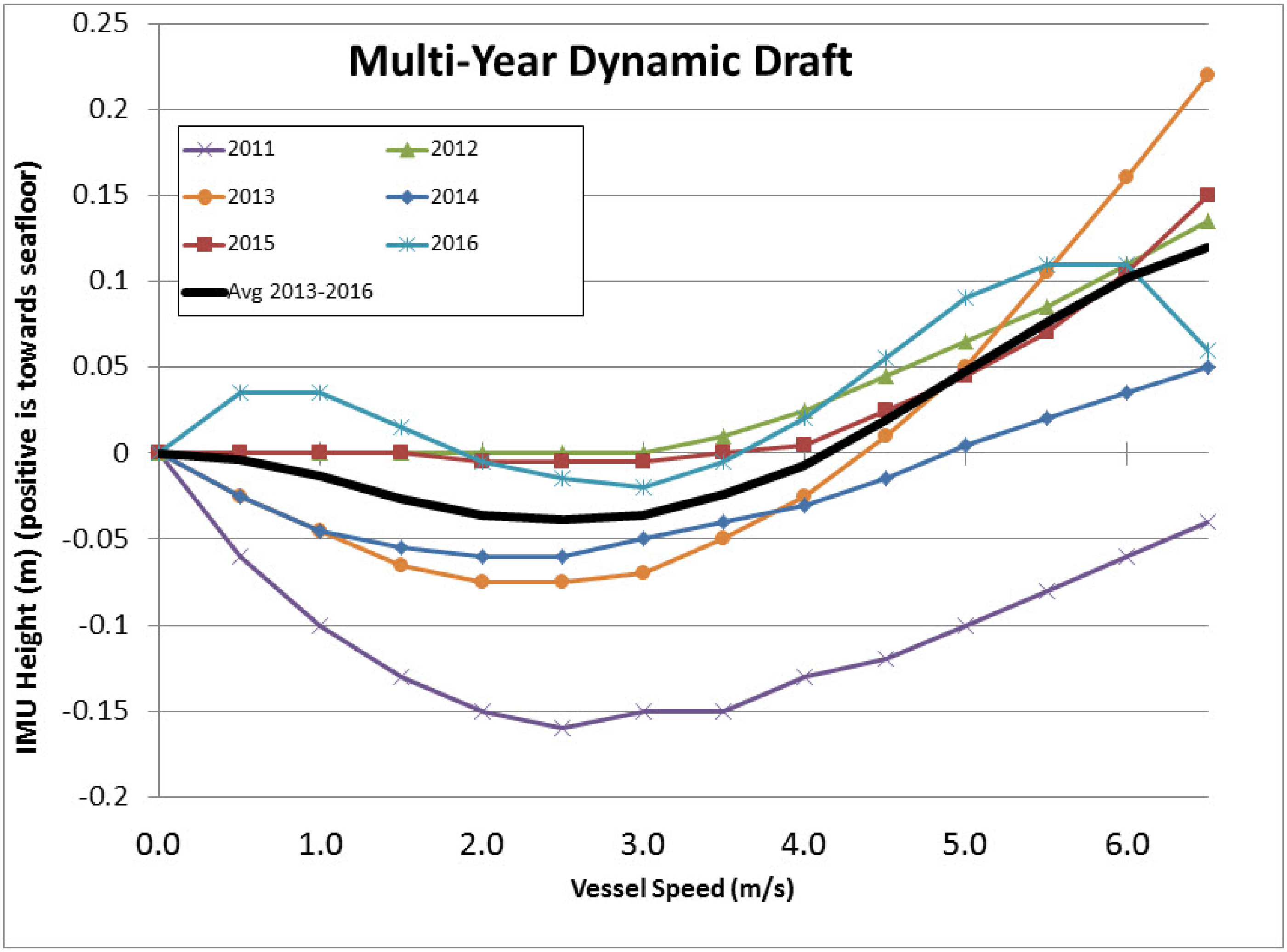


Figure 23: S250 dynamic draft derived from ERDDM methods comparison from years 2011 - 2016.

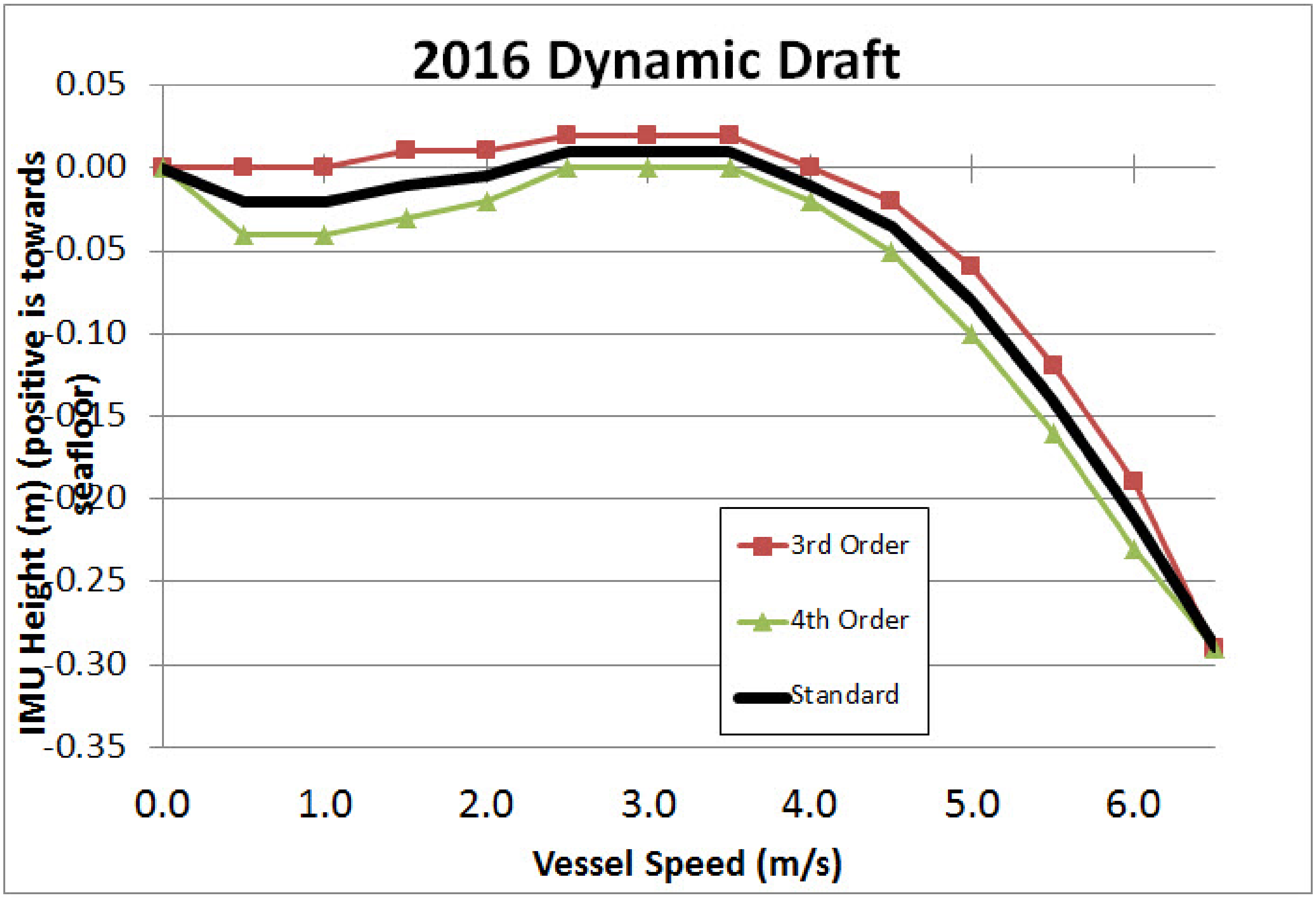


Figure 24: 2702 dynamic draft derived from ERDDM methods. Positive values are displacements of the IMU towards the sea floor. Thin lines are results from port and starboard head for third and fourth order polynomial fits.

C.2.2.3 Dynamic Draft Correctors

Vessel	S250	
Date	2016-02-21	
Dynamic Draft Table	*Speed*	*Draft*
	0.0	0.000
	0.5	0.00
	1.0	-0.01
	1.5	-0.03
	2.0	-0.04
	2.5	-0.04

	Speed	*Draft*
	3.0	-0.04
	3.5	-0.02
Vessel	S250	
Date	2015-06-14	
Dynamic Draft Table	*Speed*	*Draft*
	4.0	-0.01
	4.5	-0.02
	5.0	0.05
	5.5	0.08
	6.0	0.10
	6.5	0.12
Vessel	2702	
Date	2016-03-03	
Dynamic Draft Table	*Speed*	*Draft*
	0.00	0.00
	0.5	-0.02
	1.0	-0.02
	1.5	-0.01
	2.0	-0.01
	2.5	0.01
	3.0	0.01
	3.5	0.01
	4.0	-0.01
	4.5	-0.04
	5.0	-0.08
	5.5	-0.14
	6.0	-0.21
	6.5	-0.29

C.3 System Alignment

C.3.1 Description of Correctors

No description was provided.

C.3.2 Methods and Procedures

Methods and Procedures used follow recommendations given in Section 1.5 of the 2014 FPM.

C.3.3 System Alignment Correctors

Vessel	S250	
Echosounder	RESON 7125 Starboard 400 megahertz	
Date	2016-07-09	
Patch Test Values	*Navigation Time Correction*	0.000 seconds
	Pitch	0.620 degrees
	Roll	0.070 degrees
	Yaw	0.700 degrees
	Pitch Time Correction	0.000 seconds
	Roll Time Correction	0.000 seconds
	Yaw Time Correction	0.000 seconds
	Heave Time Correction	0.000 seconds
Vessel	S250	
Echosounder	RESON 7125 Starboard 200 kilohertz	
Date	2016-07-09	
Patch Test Values	*Navigation Time Correction*	0.000 seconds
	Pitch	0.310 degrees
	Roll	0.060 degrees
	Yaw	0.690 degrees
	Pitch Time Correction	0.000 seconds
	Roll Time Correction	0.000 seconds
	Yaw Time Correction	0.000 seconds
	Heave Time Correction	0.000 seconds
Vessel	S250	
Echosounder	RESON 7125 Port 400 kilohertz	
Date	2016-07-09	

Patch Test Values	*Navigation Time Correction*	0.000 seconds
	Pitch	0.380 degrees
	Roll	-0.140 degrees
	Yaw	-0.360 degrees
	Pitch Time Correction	0.000 seconds
	Roll Time Correction	0.000 seconds
	Yaw Time Correction	0.000 seconds
	Heave Time Correction	0.000 seconds
Vessel	S250	
Echosounder	RESON 7125 Port 200 kilohertz	
Date	2016-07-09	
Patch Test Values	*Navigation Time Correction*	0.000 seconds
	Pitch	0.370 degrees
	Roll	-0.140 degrees
	Yaw	-0.220 degrees
	Pitch Time Correction	0.000 seconds
	Roll Time Correction	0.000 seconds
	Yaw Time Correction	0.000 seconds
	Heave Time Correction	0.000 seconds
Vessel	S250	
Echosounder	RESON 7111 100 kilohertz	
Date	2014-04-16	
Patch Test Values	*Navigation Time Correction*	0.000 seconds
	Pitch	-0.86 degrees
	Roll	0.010 degrees
	Yaw	1.170 degrees
	Pitch Time Correction	0.000 seconds
	Roll Time Correction	0.000 seconds
	Yaw Time Correction	0.000 seconds
	Heave Time Correction	0.000 seconds
Vessel	2702	
Echosounder	R2Sonic 2022 400 kilohertz	
Date	2016-03-03	

Patch Test Values	*Navigation Time Correction*	0.000 seconds
	Pitch	-1.500 degrees
	Roll	-1.290 degrees
	Yaw	-0.010 degrees
	Pitch Time Correction	0.000 seconds
	Roll Time Correction	0.000 seconds
	Yaw Time Correction	0.000 seconds
	Heave Time Correction	0.000 seconds

Additional Discussion

The RESON 7111 sonar was inoperable during the 2016 field season and was not calibrated during 2016. The 7111 patch test values are retained here from the 2014 calibration period for reference only.

C.4 Positioning and Attitude

C.4.1 Description of Correctors

No description was provided.

C.4.2 Methods and Procedures

Vessel navigation and attitude is measured by the POS/MV and recorded in the Hysweep .hsx file and the RESON .s7k file. Pitch is applied real-time to the RESON 7111. Navigation and attitude measurements not applied in real time are applied during post processing in CARIS HIPS using the attitude data recorded in the .hsx or .s7k file.

The POS/MV TrueHeave data is logged within the POS/MV .000 files and applied in CARIS HIPS during post processing using the "Apply Delayed Heave" function. TrueHeave is a forward-backward filtered heave corrector as opposed to the real time heave corrector, and is fully described in section 6 of the POS/MV V5 User Guide 2011 and V4 User Guide 2009.

In most cases the Hassler used the Fugro MarineStar satellite based corrector service to provide realtime correction to the horizontal position and ellipsoid height for all data acquisition and initial processing. The corrector signal is received on the L1 channel of the POS/MV primary GPS antenna and logged directly into the POS/MV. The POS files produced during acquisition are then processed through the POSPac MMS software to produce an SBET in the WGS84 reference frame and an RMS file containing the realtime uncertainty estimates of the position and attitude data.

Alternatively, if Marinestar service isn't available, post processing of POS/MV kinematic .000 files using Applanix POSPac MMS and POSGNSS software using either IN-Fusion SmartBase, IN-Fusion SingleBase or Precise Point Positioning (PPP) processing modes. After processing and quality control analysis of the post-processed SBET files is complete, the SBET and SMRMSG files are applied to the HDCS data in CARIS HIPS using the "Load Attitude/Navigation Data" and "Load Error Data" processing tools, respectively.

The heave lever arms for S250 are configured to a point on the centerline of the vessel between the two POS IMUs. This was done to prevent long-term static roll angles from causing a steady state heave offset.

C.5 Tides and Water Levels

C.5.1 Description of Correctors

No description was provided.

C.5.2 Methods and Procedures

Unless otherwise noted in the survey Descriptive Report (DR) and/or project Horizontal and Vertical Control Report (HVCR), the vertical datum for all soundings and heights is Mean Lower Low Water (MLLW). Predicted, preliminary, and/or verified water level correctors from the primary tide station(s) listed in the Project Instructions may be downloaded from the CO-OPS website and used for water level corrections during the course of the project. These tide station files are collated to include the appropriate days of acquisition and then converted to CARIS .tid file format using FetchTides.

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

A Horizontal and Vertical Control Report (HVCR) was not created for this project.

Newer methods for handling vertical control are being developed and, if utilized, are explained in more detail in the survey DR.

C.6 Sound Speed

C.6.1 Sound Speed Profiles

C.6.1.1 Description of Correctors

No description was provided.

C.6.1.2 Methods and Procedures

Seabird .cnv and MVP .bot files are collected when necessary and converted to .svp files using NOAA's Pydro/Velocipy program. These .svp files are concatenated into one sheet specific master file per project which is then applied to HDCS data using a specified method. This method of applying sound speed to data is listed in the sheet's processing log included in the Separates submitted with the individual survey.

C.6.2 Surface Sound Speed

Surface sound speed correctors were not applied.

D. APPROVAL SHEET

This Data Acquisition and Processing Report for project OPR-G309-FH-16, Approaches to Wilmington, is respectfully submitted.

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 (3/2016); Hydrographic Survey Technical Directives 2016-1, 2016-2, 2016-3; and the Field Procedures Manual for Hydrographic Surveying (4/2014).

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 surveys H12893, H12894, H12895, H12927, H12929, H12930, H12931, H12932, H12934, and F00679 which were completed in 2016.

Approved and Forwarded:

Nick Morgan LT/NOAA	Matthew Jaskoski
LT Nicholas C Morgan, NOAA	LCDR Matthew J. Jaskoski, NOAA
Field Operations Officer	Chief of Party

Appendix I

Vessel Reports

H12932 Re-SVC Process Analysis

Approaches to Wilmington (OPR-G309-FH-16) sheet H12932 assigned to Ferdinand Hassler was selected to conduct an analysis of the need to re-SVC the sheets in this project after SBET application. This sheet was chosen due to its size and the fact that it contains multiple wrecks and bottom features. The steps for the analysis are below

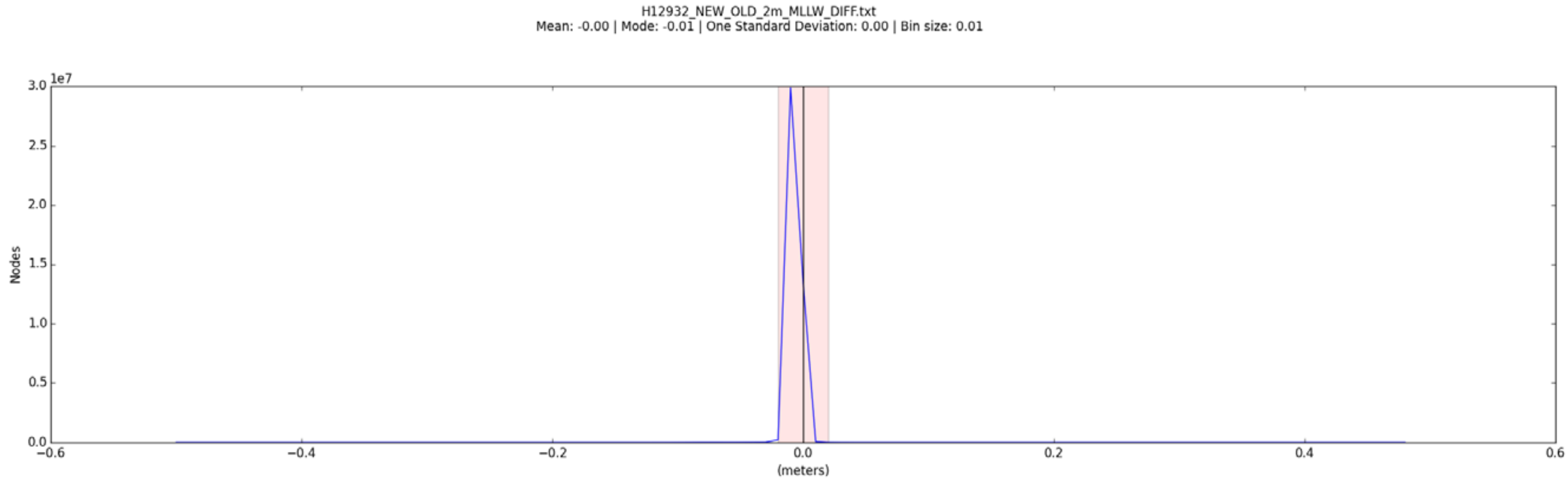
- Ensure designated soundings in the original survey were correct
- Ensure original surfaces were up to date
- Copy the original project. Rename the original project _OLD
- Re-SVC the copied project
- Re-merge the new project
- Ensure designated soundings in the new project were correct
- Create surfaces
- Difference new and old surfaces

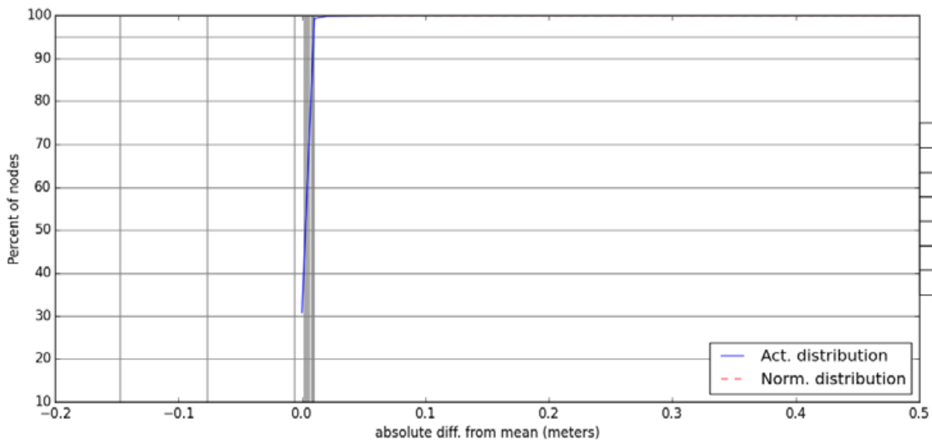
Conclusion:

- ✓ 95% of nodes in the 2m difference surface have a value of 0.01 meters or less
- ✓ 95% of nodes in the 4m difference surface have a value of 0.01 meters or less
- ✓ Largest differences were seen over wrecks or bottom topography.
- ✓ Nodal analysis over features is not indicative of actual differences in data.

NOAAS Ferdinand Hassler: P. Debroisse, J. Miller

2m Difference Surface

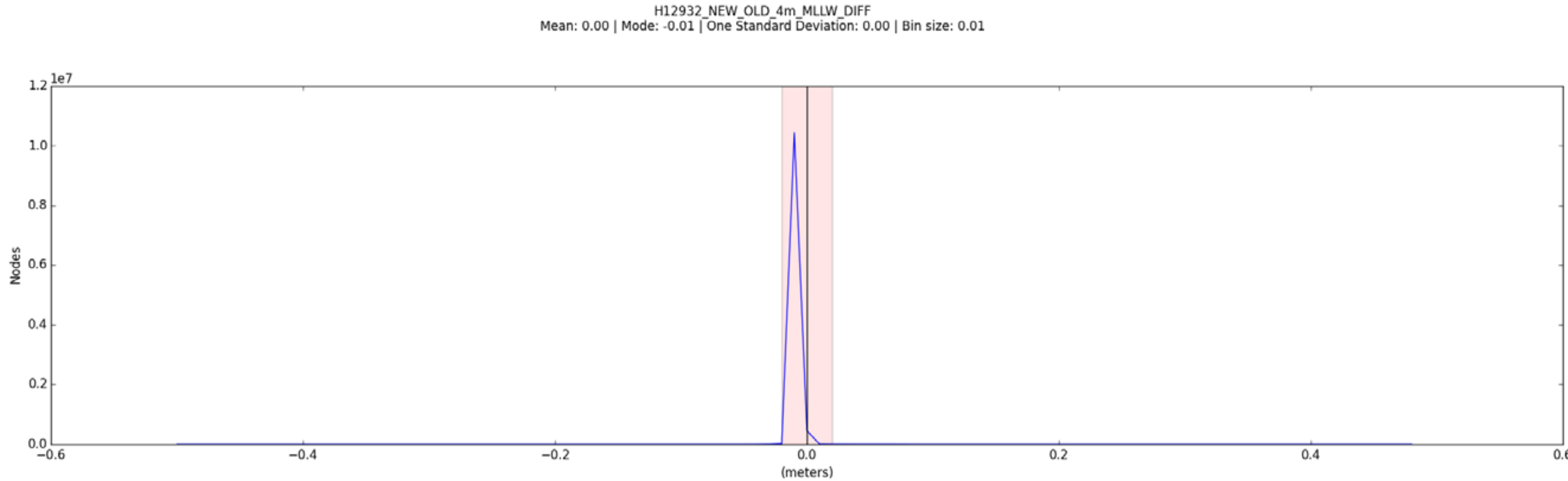


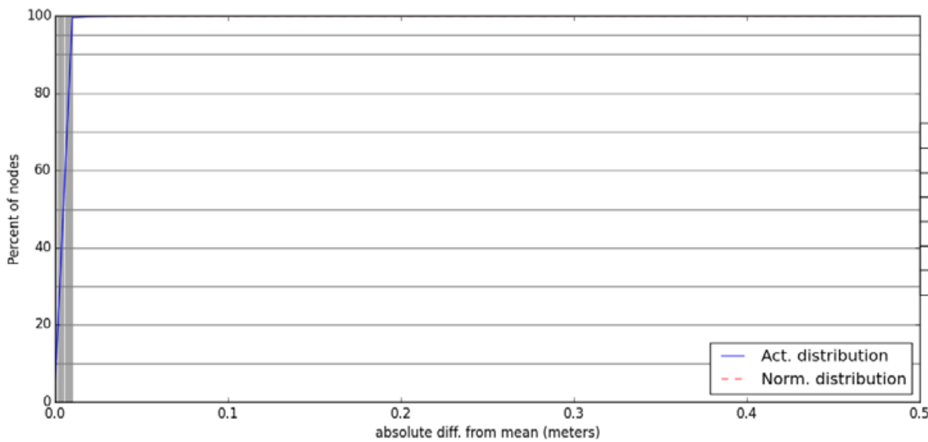


Percent of nodes	Deviation (m)
50%	+/- 0.00
60%	+/- 0.00
70%	+/- 0.01
80%	+/- 0.01
90%	+/- 0.01
95%	+/- 0.01

These stats were created using the Pydro BSB Surface ASCII Export Stats tool. As is seen, 95% of all nodes in the 2 meter difference surface are +/-0.01 meters.

4m Difference Surface

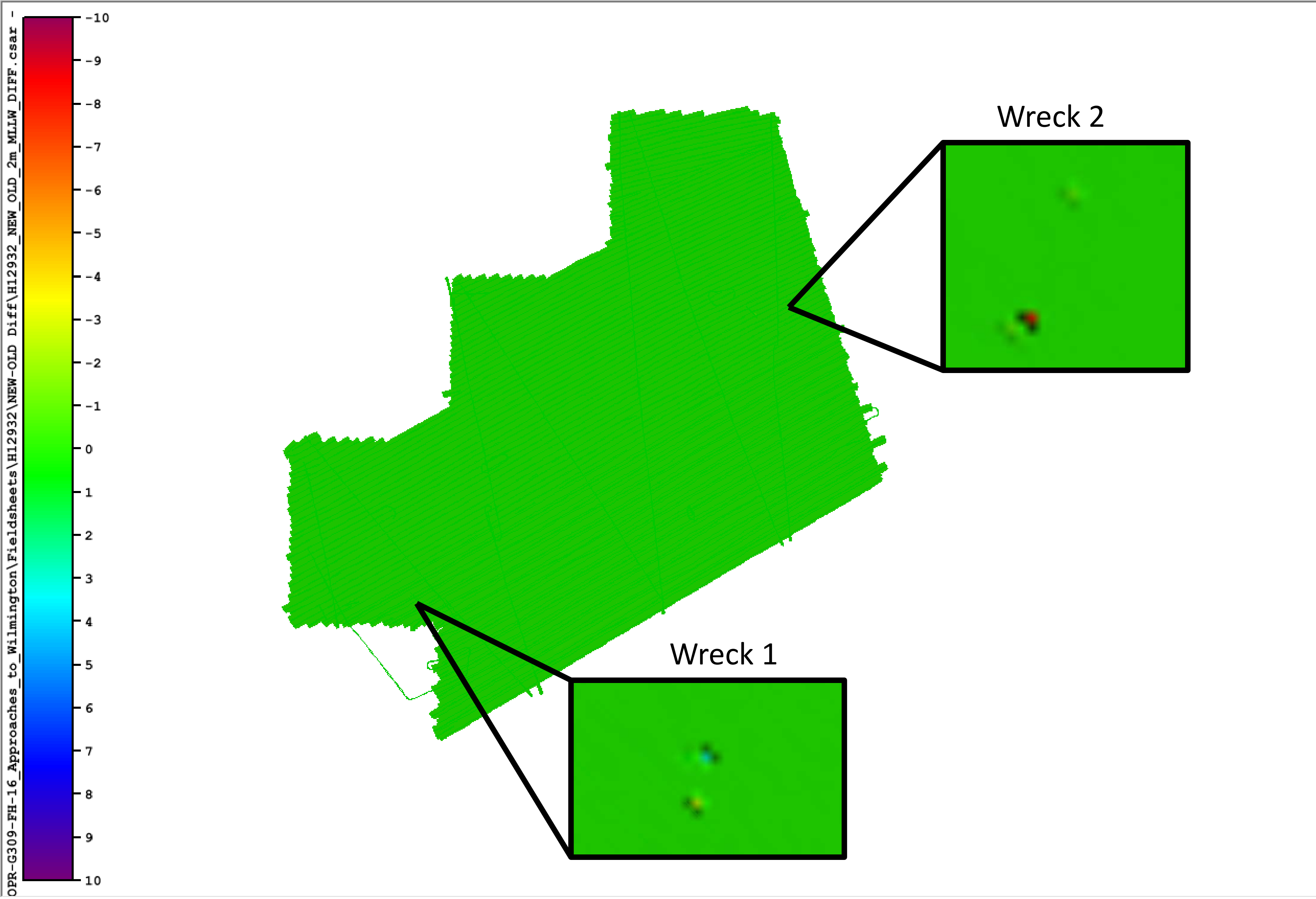




Percent of nodes	Deviation (m)
50%	+/- 0.00
60%	+/- 0.01
70%	+/- 0.01
80%	+/- 0.01
90%	+/- 0.01
95%	+/- 0.01

These stats were created using the Pydro BSB Surface ASCII Export Stats tool. As is seen, 95% of all nodes in the 4 meter difference surface are +/-0.01 meters.

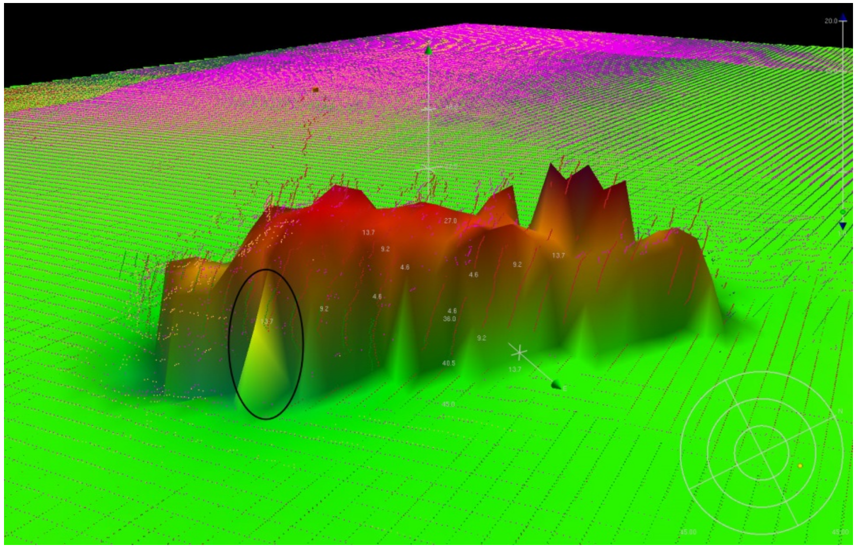
- In the 2m difference surface, 5 nodes had a difference greater than 1m with a max differences of -8.2m and 3.1m. All of these larger differences occurred over features. The 8.2m difference occurred where one surface's node referenced the feature and the other surface's node referenced the seafloor immediately next to the feature.
- In the 4m difference surface 44 nodes had a difference 0.5m or greater with a max difference of -0.7m and 0.6m.
- A review of all non-zero difference nodes indicated the apparent vertical difference was in fact due to horizontal differences in surface node structure.
- Subset evaluations indicated typical vertical differences between SV processing methods of 1cm or less.



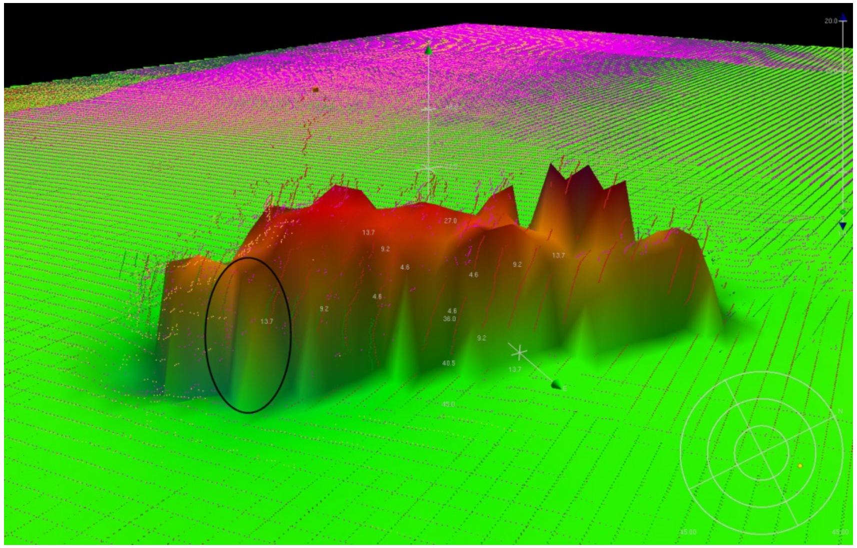
2m difference surface and locations of large differences. Wreck 1 max difference: 3.1m. Wreck 2: max difference 8.2m.

Old/New surfaces in Subset Editor

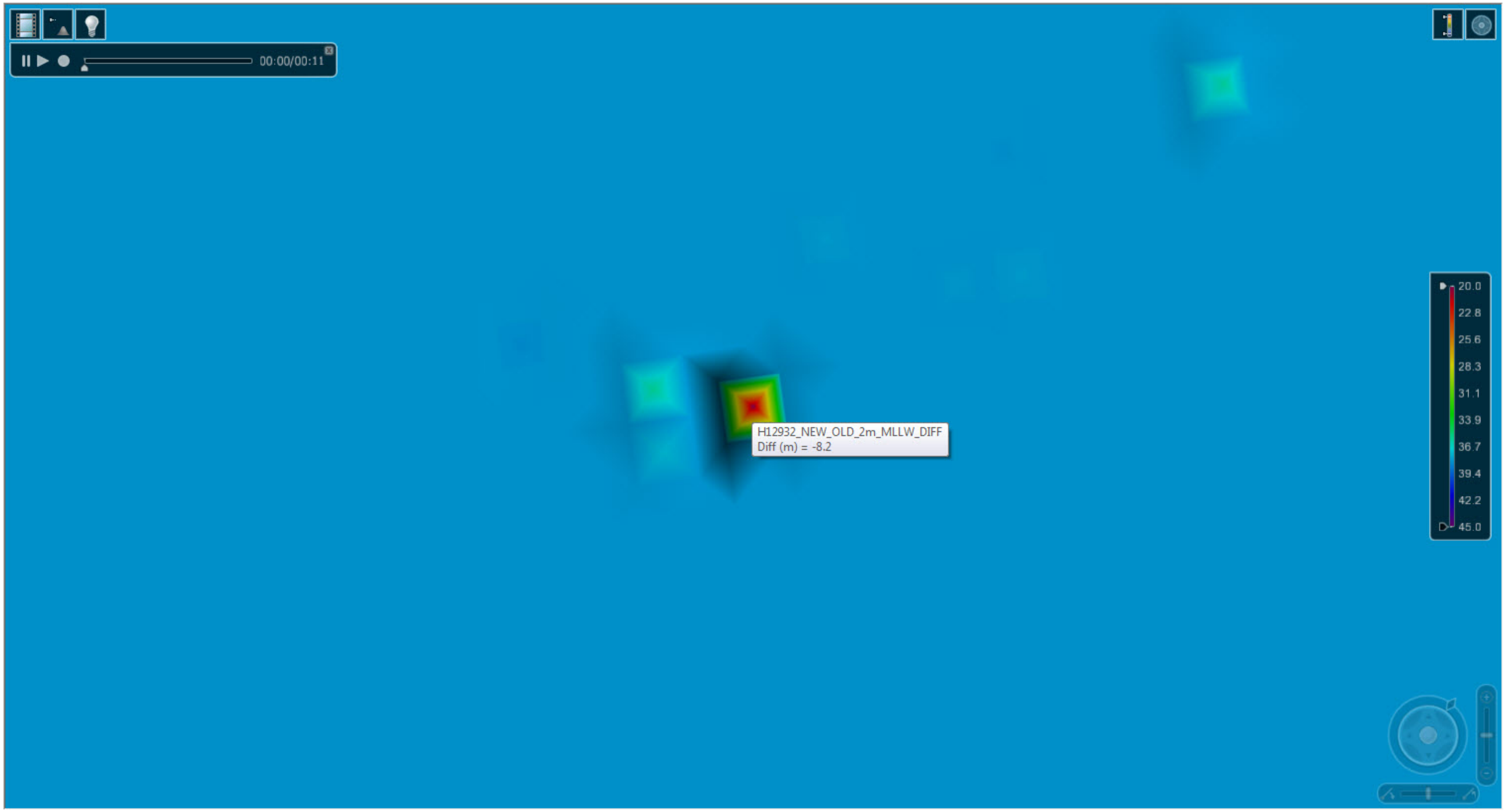
Without SVC after SBETS



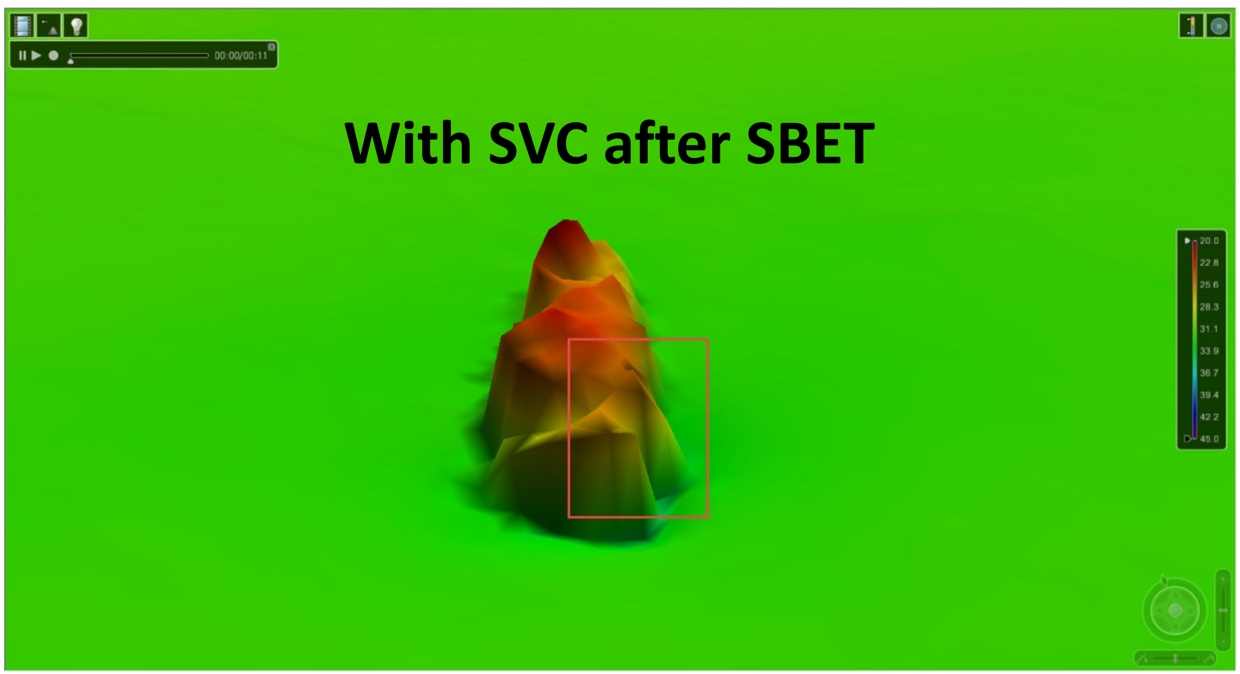
With SVC after SBETS

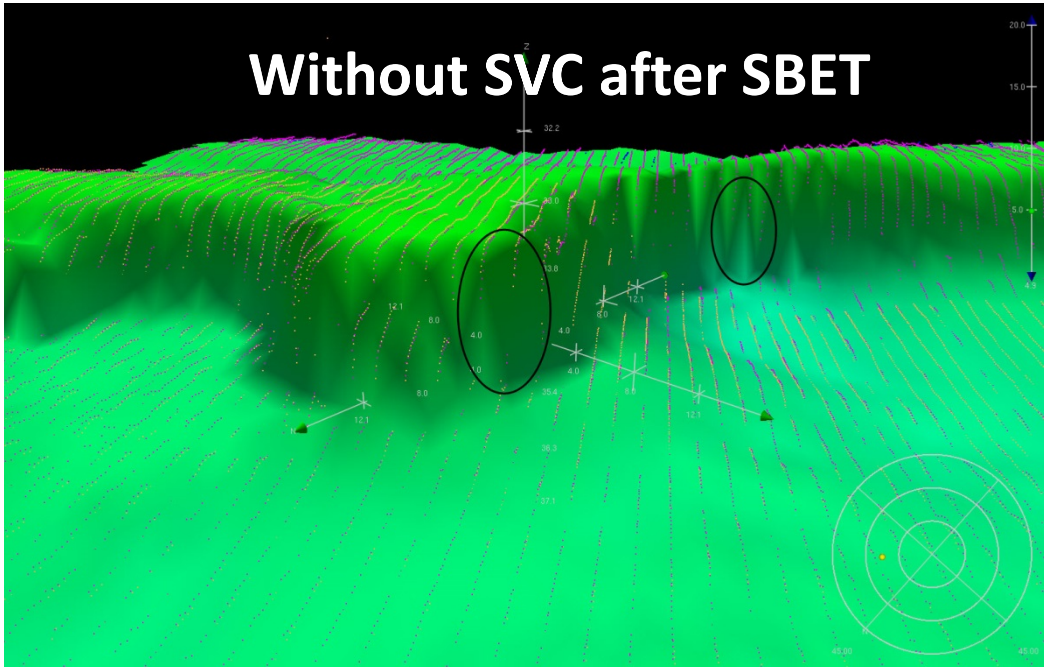


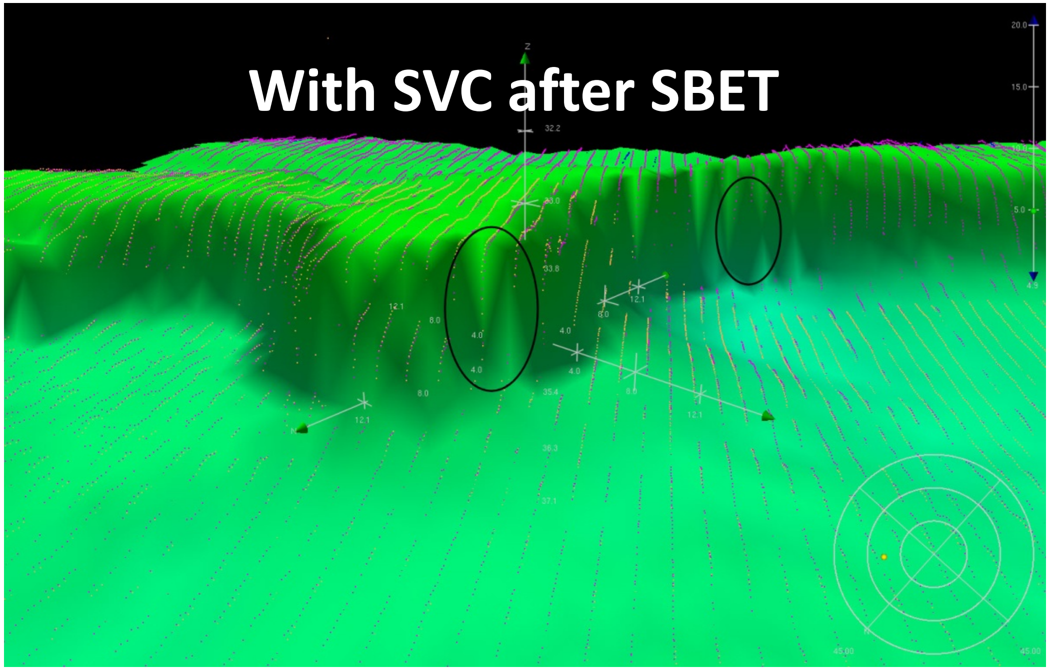
The -8.2m differenced node

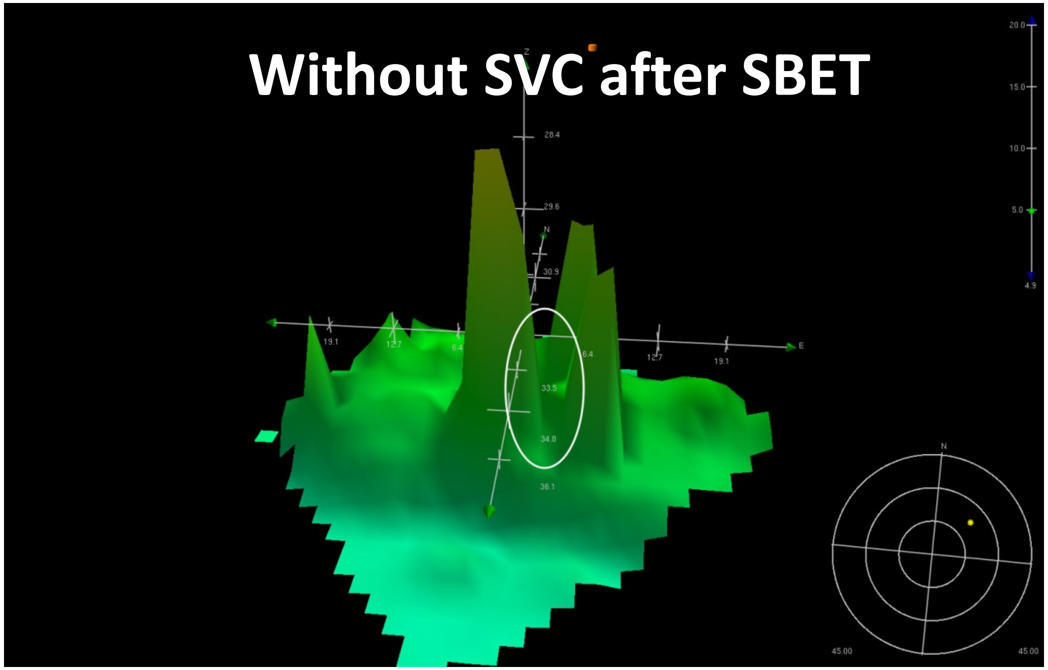


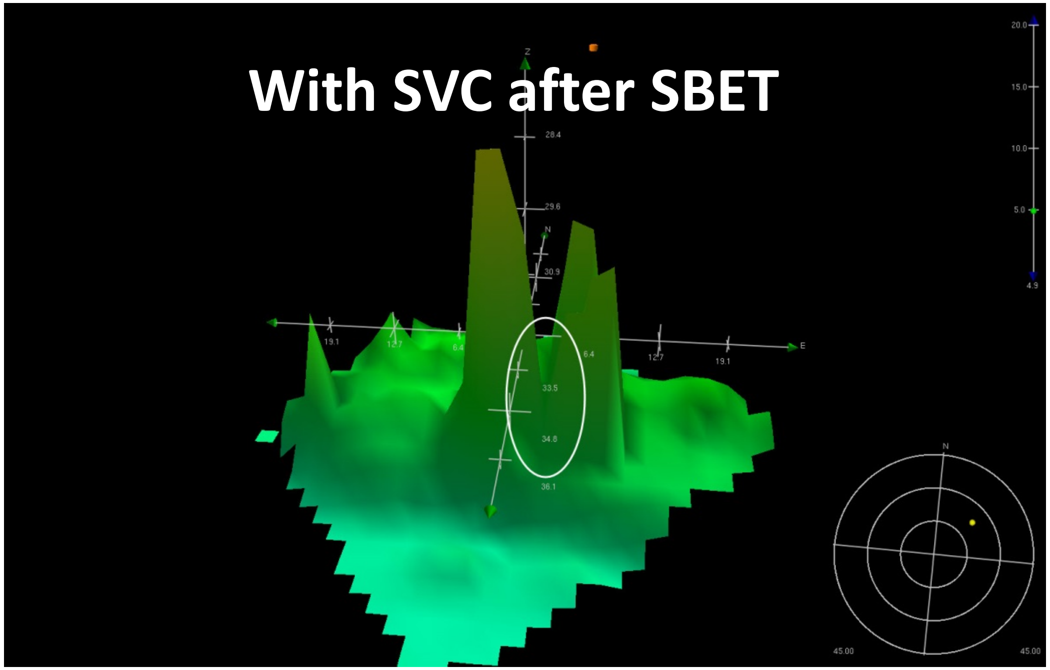

Without SVC after SBET

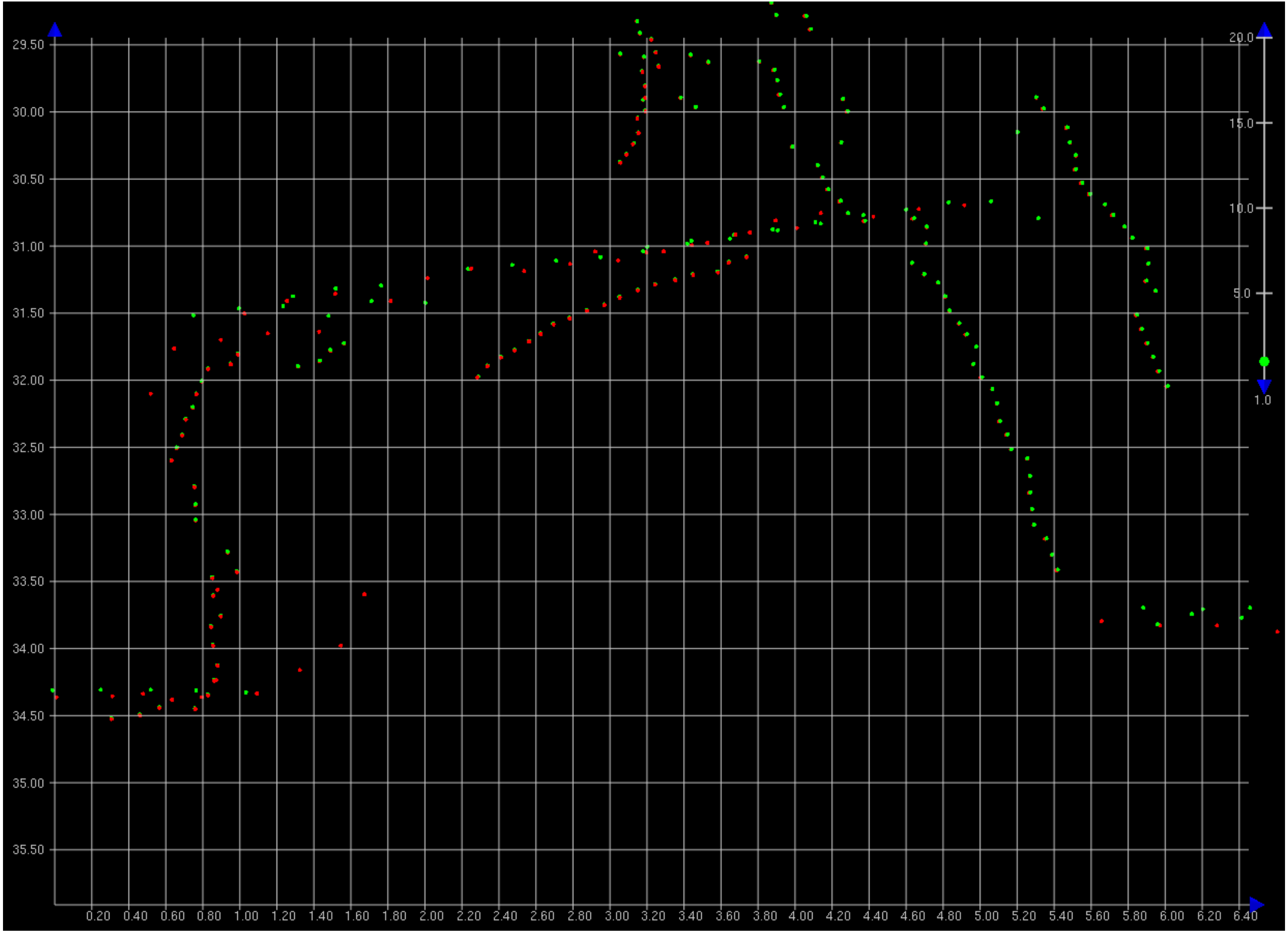

With SVC after SBET
20.0
22.8
25.6
28.3
31.1
33.9
36.7
39.4
42.2
45.0


Without SVC after SBET

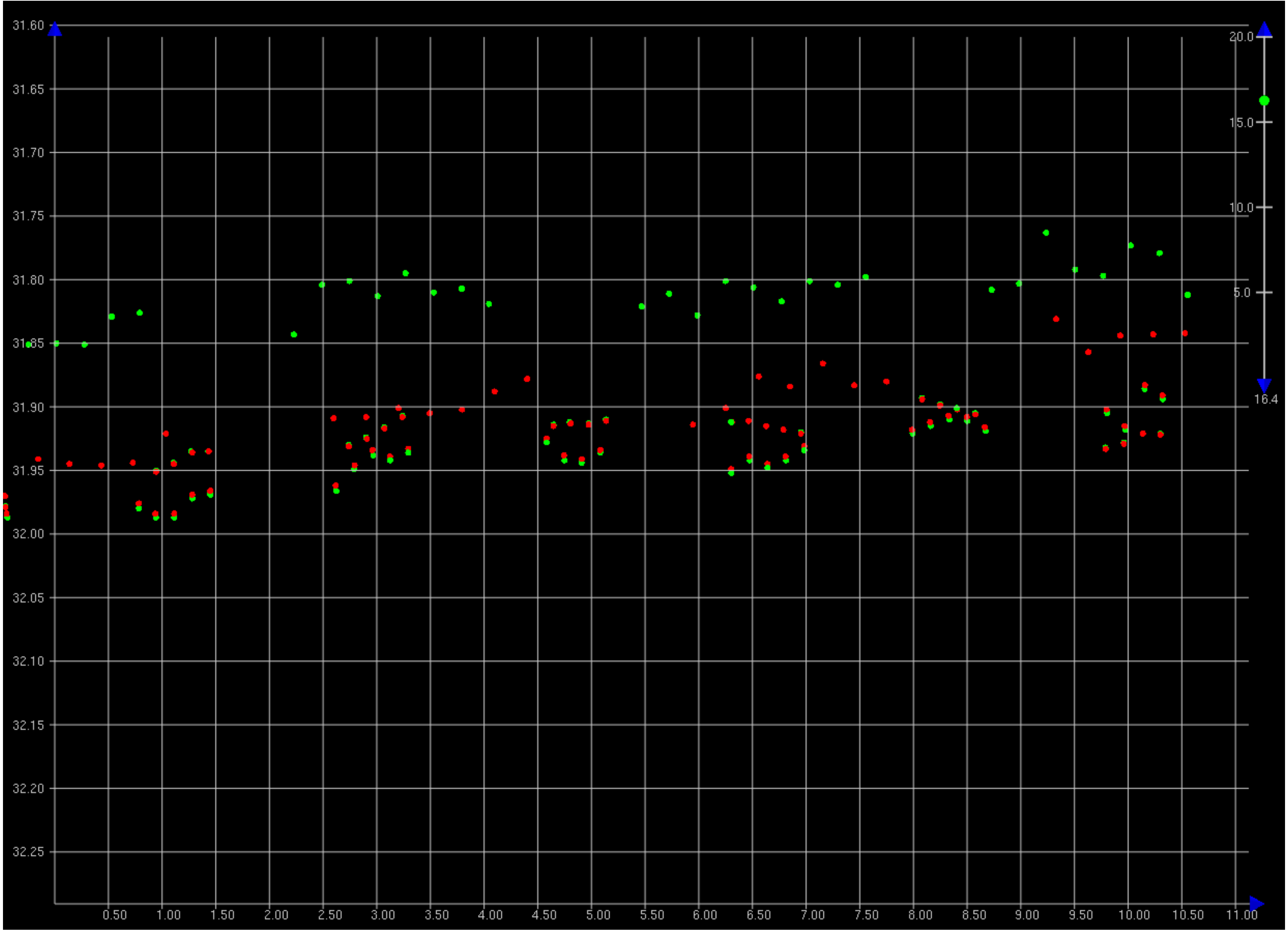

With SVC after SBET


Without SVC after SBET

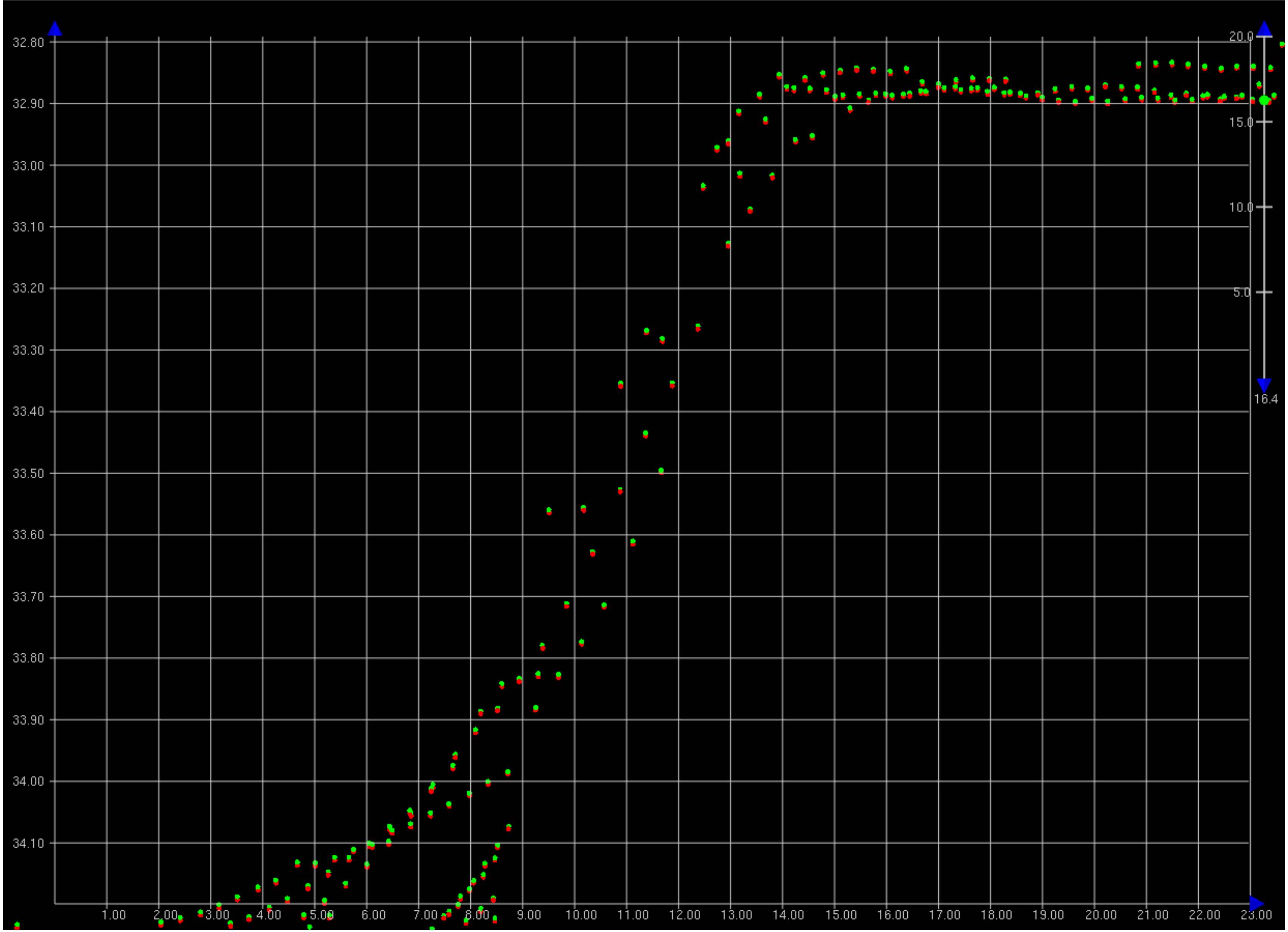

With SVC after SBET



An example of sounding difference over a wreck. Green is with re-SVC, Red is old. Note that a query of soundings that appear isolated showed that they are co-located with soundings of the opposite color.



An example of sounding difference over a flat surface. Green is with re-SVC, Red is old. Note that a query of soundings that appear isolated showed that they are co-located with soundings of the opposite color.



An example of sounding difference over a steep slope. Green is with re-SVC, Red is old.

Final report

SURVEY REPORT

SHIP: M286 SWATH
FERDINAND R. HASSLER

LOCATION: PASCAGOULA, MS

DATE: 7/18-7/26, 2009
And **11/4, 2009**

PURPOSE:
Determine the ship's centerline, roll, and pitch. Install benchmarks, install the master reference plane in the same planes as the measured roll, pitch, and azimuth of the ship. Assist the shipyard to install the IMUs parallel to the centerline, and in the same plane as the ship's roll and pitch. Assist the shipyard in installing the transducers in the same plane as roll, pitch and azimuth of the ship. Measure and spot the draft marks.

PERSONNEL:
Eric Kostelak
Brian Kloter
Raymond Impastado
John Miskimmin

EQUIPMENT LIST:
WILD T2 THEODOLITE SN: 169786 Calibration Expiration Date; 12/19/09

WILD T2 THEODOLITE SN: 155062 Calibration Expiration Date; 12/19/09

WYLER CLINO 2000 CLINOMETER SN: M4416 Calibration Expiration Date; 07/10/10

TOPCON GTS-301 One Second Electronic Total Station, Serial number GU1193 Calibration Expiration Date; 07/12/09

WILD NA1 AUTO LEVEL: SN 472810 Calibration Expiration Date; 07/12/09

Procedures:

1. Establish a baseline in relation to the centerline of both pontoons.
   A. Locate points on each of the pontoons to determine centerline
   B. Measure the elevation differences of the points. Take the average of these to determine the pitch and roll of each pontoon.

2. Take the average of the measurements of the two pontoons for roll, pitch, and centerline. The result can then be used as the Master reference.

3. Create a traverse, in a level plane, around the ship using the established baseline as a reference. Set various points that will be used to locate the master reference block, IMUs, bench marks, transducers, and antennas.

4. Locate, set and secure the master reference block to within 9 arc seconds of the calculated roll, pitch, and centerline values.

5. Once the MRB has set for a day, confirm the measurements relative to the results of step 2. If the measurements are within the two values used in Step 2, these values will become the Final Master Reference, which all further measurements will be referenced to.

6. Locate IMU foundations, adjust to be level with roll and pitch, and aligned with centerline.

7. Establish bench marks that are aligned to the centerline in any areas that require future measurements.

8. For transducers, on the bottom of the hull, establish punch marks aligned to the centerline that can be used to align the transducers to the centerline.

9. Run a closed level loop from the master reference block to all bench marks, Transducers, antennas, and sensors to determine their elevation values relative to the reference. (Z axis).

10. Using established elevation points within the traverse, determine the correct locations for all draft marks.

11. Work with the shipyard to determine the correct alignment of the transducers.

METHODS

All angles at intersections were turned 4 times, 2 in regular, and 2 in inverted position. All other angles were turned 2 times, once in regular, and once in inverted position.

Slope distances were measured with a zenith angle in the regular and inverted Position.

The Traverse was closed and computed for accuracy.

Results

MRB

After the MRB has set up for 24 hours, it was found the chock fast had caused an 18 second movement in roll. As this small value was well within the average of the two pontoons, the final reference was shifted to the MRB values.

IMU

During measurements of the IMUs, we discovered it was impossible to meet the specification to be level to the roll and pitch within 90 arc seconds using the existing mounts. The shipyard manufactured a double plate separated by three threaded rods, which allowed fine adjustment in two planes (roll and pitch). The IMUs were aligned to zero measurable azimuth error, and to within 5 arc seconds in roll and pitch relative to the MRB.

TRANSDUCERS

7125

During measurements it became apparent that it was impossible to meet the roll and pitch specification on the multibeam transducer mounts. There was no measurable azimuth error on either 7125 transducer mount, when the welding was finished. The shipyard came up with the roll and pitch solution of machining the surfaces in place once the mounting plates were completely welded out. We attended for the machine work on 8/19/09. A portable milling machine was put in place, leveled to within 5 arc seconds of the MRB plus 4.5 degrees of roll to Give the transducer mounting surfaces the specified 4.5 degree outward roll angle. See attached photo. It was agreed by all that if the milling machine was positioned correctly, the surfaces had to be correct, but as a check to confirm the process, we measured the machined surface on the port unit, and found the pitch error was zero, and the roll error was 15 seconds. This was well within the required 90 seconds.

Milling machine set up on 7125 transducer housing

7111

Like the 7125s, it was impossible to meet the roll and pitch specification on this transducer mounting plate. It too, was machined by the portable milling machine.
The machine was set up to be within 5 seconds of the MRB Pitch and Roll values.

XYZ COORDINATES TABLE

POINT	X-AXIS	Y-AXIS	Z-AXIS	DESCRIPTION
5	9.264	-7.555	7.169	POINT FP
6	9.409	6.256	7.168	POINT FS
7	3.491	-7.478	7.176	POINT MP
8	3.872	6.168	7.178	POINT MS
9	-4.035	-7.561	7.168	POINT AP
10	-4.022	6.258	7.169	POINT AS
15	9.326	-0.652	7.168	CENTERLINE
18	-4.017	-0.652	7.168	CENTERLINE
19	16.343	2.530	-5.065	STARBOARD BENCH MARK TOP WHEEL HOUSE
20	16.343	-0.653	-5.064	MID BENCH MARK TOP WHEEL HOUSE
21	16.343	-3.836	-5.066	PORT BENCH MARK TOP WHEEL HOUSE
25	-1.336	0.001	0.160	AFT BENCH MARK MASTER REFERENCE PLATE
26	0.000	0.000	0.000	MASTER REFERENCE PLATE
27	-0.353	0.000	0.161	FWD BENCH MARK MASTER REFERENCE PLATE
28	13.428	-8.960	-2.496	PORT BENCH MARK BRIDGE WING
29	13.428	-5.592	-2.476	STARBOARD BENCH MARK BRIDGE WING
30	7.115	5.836	7.154	FWD PUNCH MARK ADCP
31	5.765	5.835	7.145	AFT PUNCH MARK ADCP
33	7.841	6.846	7.167	FWD PUNCH MARK RESON 7125 STARBOARD PONTOON
34	5.025	6.847	7.168	AFT PUNCH MARK RESON 7125 STARBOARD PONTOON
36	5.022	-8.169	7.157	AFT PUNCH MARK RESON 7125 PORT PONTOON
37	7.792	-8.169	7.154	FWD PUNCH MARK RESON 7125 PORT PONTOON
39	15.307	6.610	6.843	AFT PUNCH MARK RESON 7111
40	16.098	6.611	6.771	FWD PUNCH MARK RESON 7111
41	10.822	5.864	7.169	FWD PUNCH MARK MDS* STARBOARD PONTOON
42	9.818	5.863	7.172	AFT PUNCH MARK MDS* STARBOARD PONTOON
43	10.608	-7.081	7.177	FWD PUNCH MARK MDS* PORT PONTOON
44	9.762	-7.080	7.175	AFT PUNCH MARK MDS* PORT PONTOON
45	-13.926	-0.615	0.105	AFT MID BENCH MARK BACK DECK
46	-9.031	-0.615	0.125	FWD BENCH MARK BACK DECK

POINT	X-AXIS	Y-AXIS	Z-AXIS	DESCRIPTION
47	-13.926	6.471	0.114	STARBOARD BENCH MARK BACK DECK
48	-13.926	-7.697	0.093	PORT BENCH MARK BACK DECK
51	5.891	-6.878	5.839	IMU PORT PONTOON (OLD LOCATION)
52	5.923	5.428	5.840	IMU STARBOARD PONTOON (OLD LOCATION)
53	17.655	6.584	6.890	RESON 7111 CENTER OF PLATE
54	6.265	6.774	7.095	PORT EDGE RESON 7125 STARBOARD PONTOON
55	6.265	6.805	7.093	RESON 7125 STARBOARD PONTOON
56	6.223	-8.078	7.087	STARBOARD EDGE RESON 7125 PORT PONTOON
57	6.223	-8.109	7.085	RESON 7125 PORT PONTOON
58	16.039	5.417	2.563	INBOARD DRAFT MARK FRAME 4 STARBOARD
59	16.025	-6.711	2.567	INBOARD DRAFT MARK FRAME 4 PORT
60	-11.204	5.626	2.588	INBOARD DRAFT MARK FRAME 46 STARBOARD
61	-11.208	-6.870	2.562	INBOARD DRAFT MARK FRAME 46 PORT
62	16.040	7.458	2.565	OUTBOARD DRAFT MARK FRAME 4 STARBOARD
63	-11.208	7.462	2.588	OUTBOARD DRAFT MARK FRAME 46 STARBOARD
64	16.025	-8.735	2.570	OUTBOARD DRAFT MARK FRAME 4 PORT
65	-11.205	-8.711	2.555	OUTBOARD DRAFT MARK FRAME 46 PORT
66	6.273	-9.907	5.789	PORT BENCH MARK IMU PORT PONTOON
67	6.273	-5.007	5.861	STARBOARD BENCH MARK IMU PORT PONTOON
68	6.624	3.666	5.862	PORT BENCH MARK IMU STARBOARD PONTOON
69	6.624	8.571	5.798	STARBOARD BENCH MARK IMU STARBOARD PONTOON
70	5.861	-6.865	5.767	IMU PORT PONTOON
71	5.885	5.381	5.768	IMU STARBOARD PONTOON
72	-20.247	-0.609	-4.327	BOTTOM OF CENTER BLOCK "A" FRAME
73	11.205	-1.904	-7.782	BOTTOM OF GPS ANTENNAE PORT LOWER
74	10.488	-1.896	-9.774	BOTTOM OF GPS ANTENNAE PORT UPPER
75	11.180	0.594	-7.776	BOTTOM OF GPS ANTENNAE STARBOARD LOWER
76	10.455	0.589	-9.776	BOTTOM OF GPS ANTENNAE STARBOARD UPPER

RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

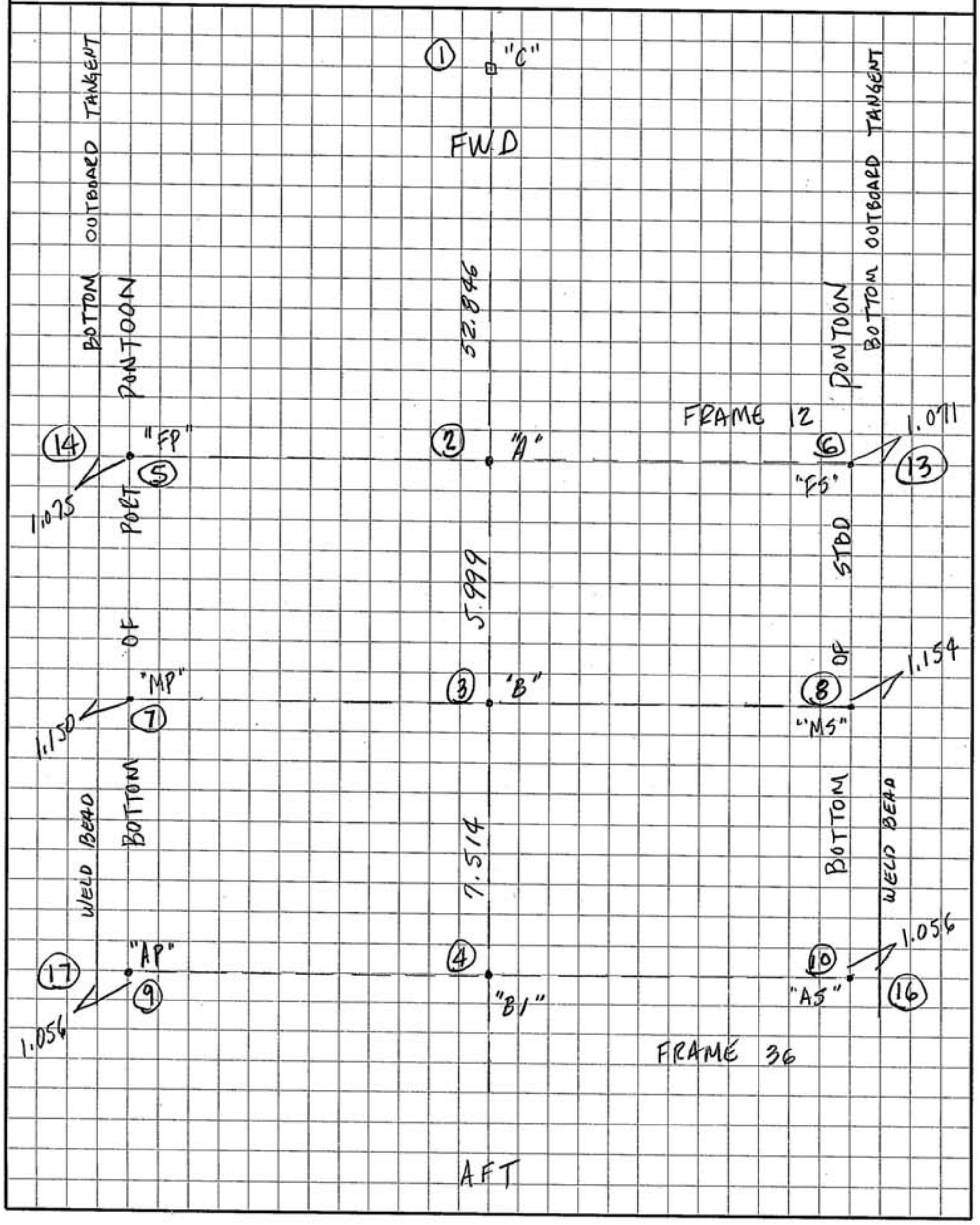
SCALE: 1" = NONE

JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09 7-26-09 SHEET NO.: 1



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FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09 SHEET NO.: 1A

∡ 1	∡ 2	AVG.	Z∡1	Z∡2	AVG.	DIST.	PT.
INST. ON PT "A" - B.S. @ PT "C"							
89°20'25"	89°20'30"	89°20'28"	87°41'56"	272°17'59"	87°41'59"	6.779	"FS"
268°11'37"	268°11'42	268°11'40"	87°54'43"	272°05'12"	87°54'45"	7.044	"FP"
INST. ON PT "B" - B.S. @ PT "C"							
85°25'42"	85°25'46"	85°25'44	88°45'06"	271°14'57"	88°45'05"	6.770	"MS"
270°02'26"	270°02'28"	270°02'27"	88°53'12"	271°07'02"	88°53'05"	6.895	"MP"
INST. ON PT "B1" - B.S @ PT "C"							
88°39'43"	88°39'43"	88°39'43	87°52'44"	272°07'20"	87°52'42"	6.932	"AS"
269°56'40"	269°56'48"	269°56'44"	87°54'20"	272°05'48"	87°54'16"	6.897	"AP"

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SCALE: 1" - NONE

JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09 SHEET NO.: 2

STA	BS	HI	FS	ELEV	DESCRIPTION	
				0.000	(ASSUMED ELEVATION) PT. "B1"	-8.526
	0.780	0.780				
			-0.564	1.344	"AP"	-7.182
			-0.578	1.358	"AS"	-7.168
			0.812	-0.032	PT "B"	-8.558
	1.017	0.985				
			-0.363	1.348	"MP"	-7.178
			-0.376	1.361	"MS"	-7.~~216~~ 165
			-0.379	1.364	"FP"	-7.162
			-0.395	1.380	"FS"	-7.146
	-0.416	0.964				
			-0.400	1.364	"FP"	-7.162
			-0.385	1.349	"MP"	
			-0.397	1.361	"MS"	
			0.996	-0.032	"PT" B"	
	0.807	0.775				
			-0.583	1.358	"AS"	
			-0.569	1.344	"AP"	
			0.775	0.000	✓ PT "B1"	

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SCALE: 1" = NONE

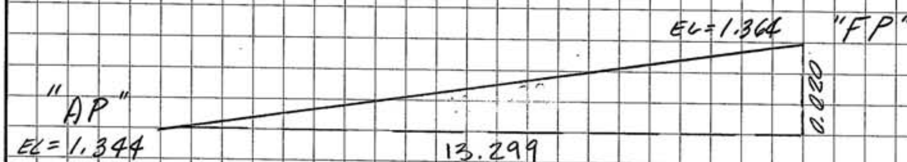
JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

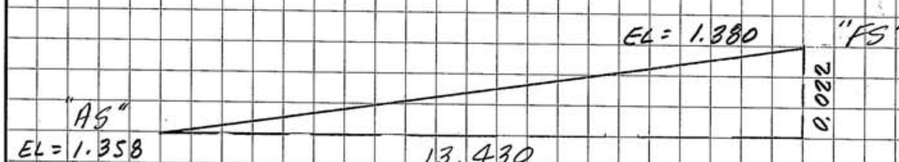
DATE: 7-18-09 7-26-09 SHEET NO.: 3

BOTTOM OF PORT PONTOON



PITCH = 0°05'10"

BOTTOM OF STARBOARD PONTOON



PITCH = 0°05'38"

PITCH AVERAGE = 0°05'24"
BOW HIGH

RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

SCALE: 1" = NONE

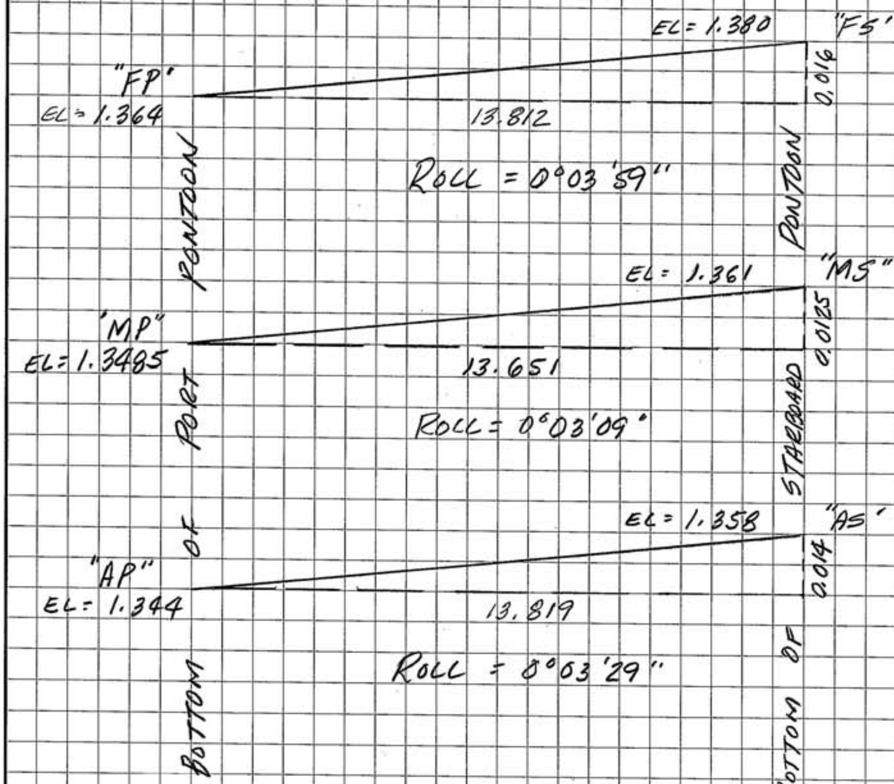
JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

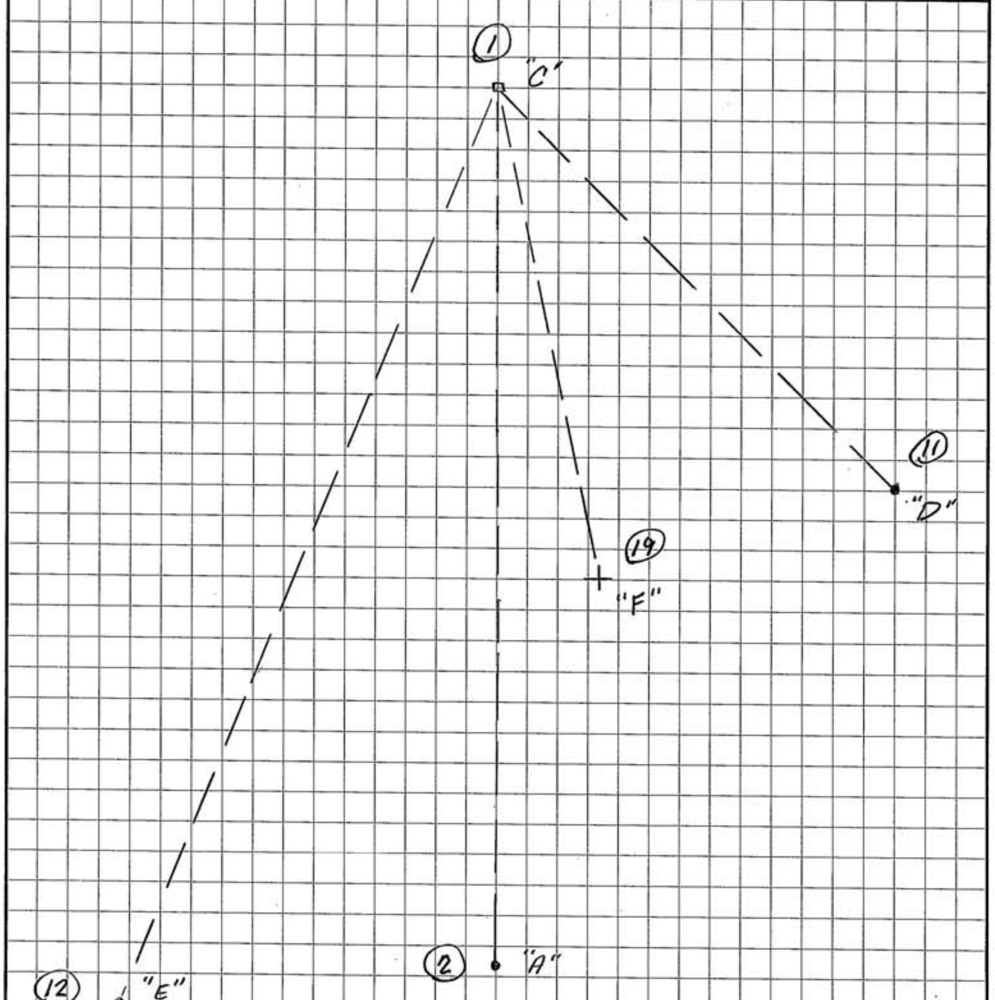
DATE: 7-18-09
7-26-09

SHEET NO.: 4



ROLL AVERAGE = 0°03'32"
STARBOARD HIGH

RAYMOND C. IMPASTATO PROFESSIONAL LAND SURVEYOR 139 RANCH ROAD SLIDELL, LOUISIANA 70460 PHONE NO: (985) 774-1955 SCALE: 1" = NONE	JOB: FERDINAND R. HASSLER M286 SWATH PASCAGOULA, MISSISSIPPI FIELD CREW: R.I., E.K., J. M. & B. K. CALCULATED BY: R. IMPASTATO DATE: 7-18-09 7-26-09 SHEET NO.: 5



INST. ON PT "C" - B.S. @ PT "A"

∡ 1	∡ 2	AVG	Z ∡1	Z ∡2	AVG	DIST.	PT.
327°52'02"	327°52'05"	327°52'03"	90°02'07	269°57'50"	90°02'09"	50.572	"D"
24°59'01"	24°59'07"	24°59'04"	81°38'44	278°21'12"	81°38'46"	66.533	"E"
356°18'52"	356°18'56"	356°18'54	73°44'26"	286°15'37"	73°44'25"	47.908	"F"

RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

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PHONE NO: (985) 774-1955

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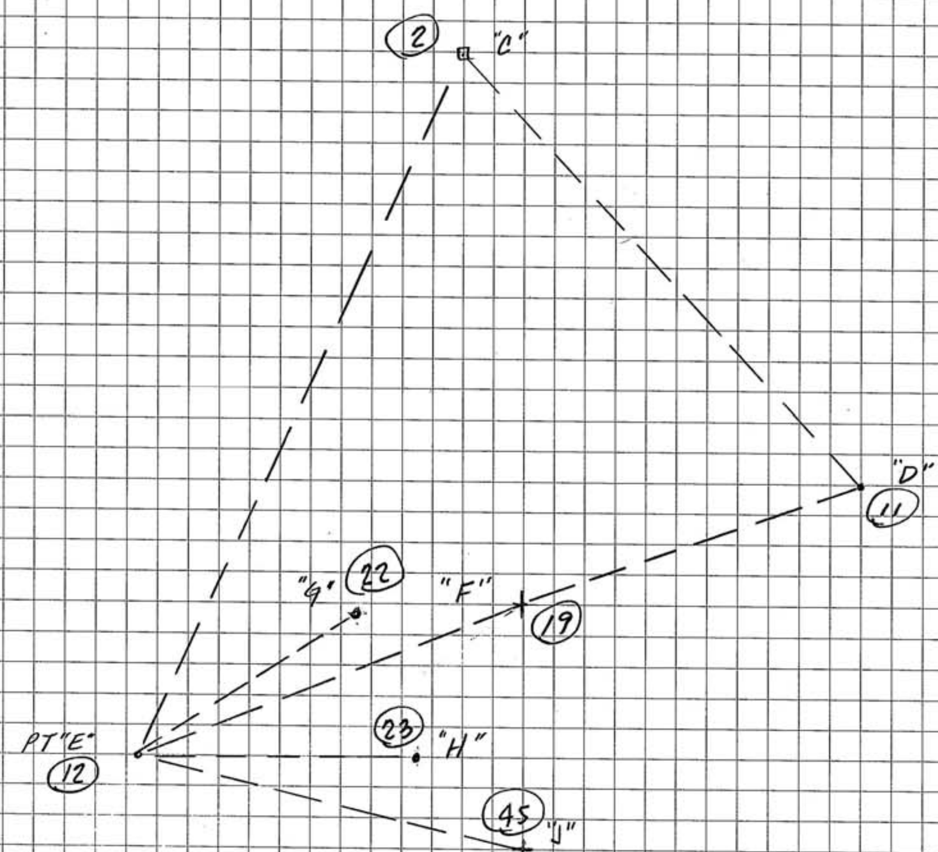
JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09 / 7-26-09 SHEET NO.: 6



INST. ON POINT "E" - B.S. @ PT "C"

∡1	∡2	AVG	Z∡1	Z∡2	AVG	DIST.	PT.
40°53'50"	40°53'44"	40°53'47"	83°41'57"	276°18'12"	83°41'53"	33.906	"F"
37°40'49"	37°40'52	37°40'51"	87°24'16"	272°35'54"	87°24'11"	23.410	"G"
59°49'14"	59°49'17"	59°49'16"	93°09'48"	266°50'20"	93°09'44"	23.114	"H"
95°35'50"	95°35'46"	95°35'48"	92°05'16"	267°54'37"	92°05'20"	32.496	"J"
INST ON PT "D" - B.S. @ PT "C"							
294°49'26"	294°49'27"	294°49'27"	61°04'08"	298°55'49"	61°04'10"	27.580	"F"

RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

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PHONE NO: (985) 774-1955

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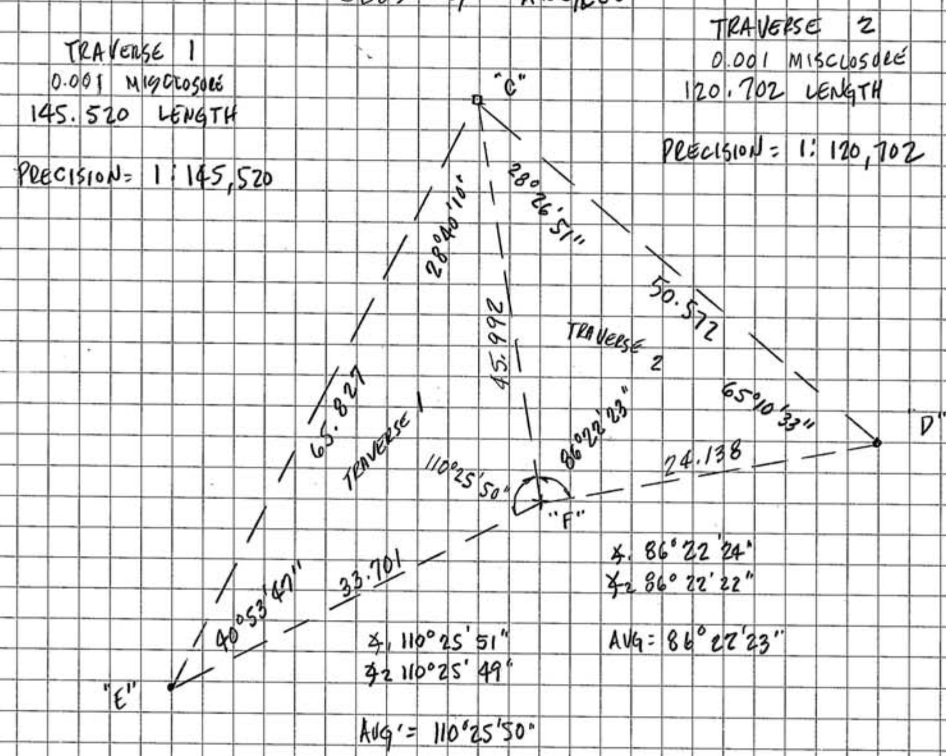
JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09 7-26-09 SHEET NO.: 7

CLOSING ANGLES



	ADJUSTED ∡'S
40°53'47"	40°53'51"
28 40' 10"	28°40'14"
110 25' 50"	110°25'55"
179°59'47"	180°00'00"

13 SECOND MISCLOSURE

	ADJUSTED ∡'S
28°26'51"	28°26'55"
86°22'23	86°22'28"
65°10'33	65°10'37"
179°59'47	180°00'00"

13 SECOND MISCLOSURE

RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

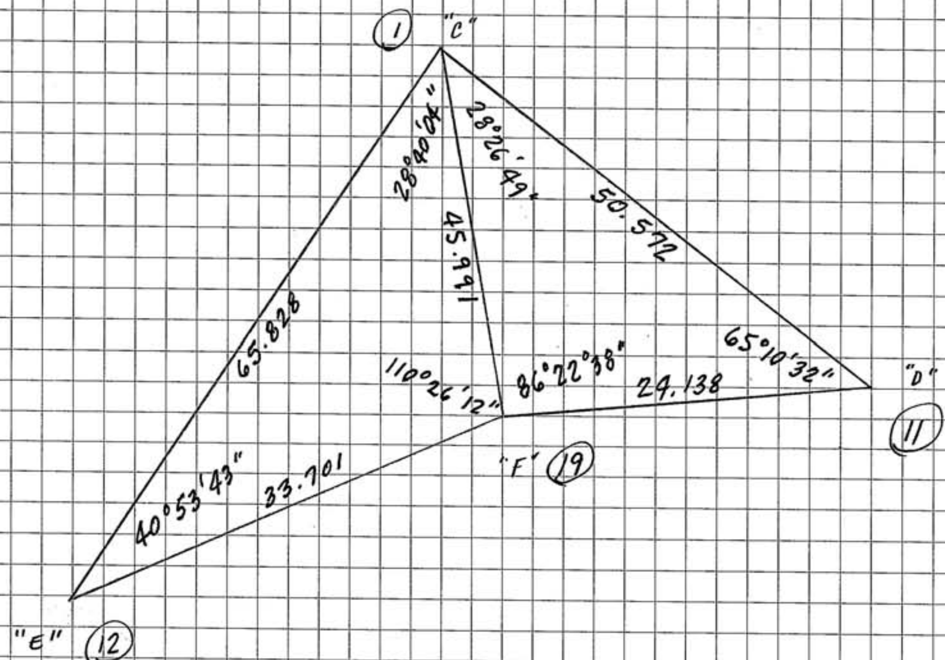
SCALE: 1" = NONE

JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I., E.K., J. M. & B. K.

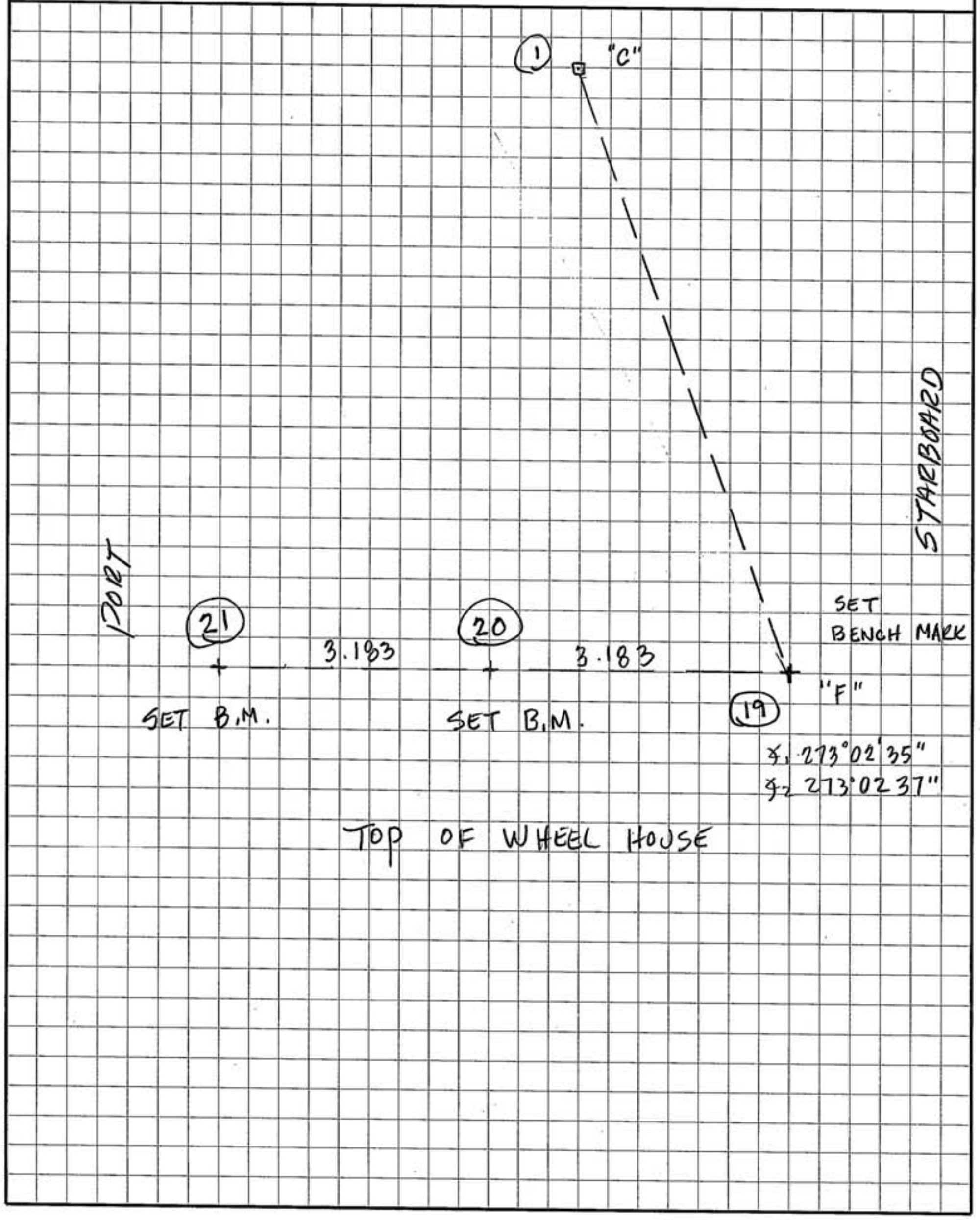
CALCULATED BY: R. IMPASTATO

DATE: 7-18-09 7-26-09 SHEET NO.: 8



ANGLES AND DISTANCES
AFTER ADJUSTMENTS

RAYMOND C. IMPASTATO PROFESSIONAL LAND SURVEYOR	JOB: FERDINAND R. HASSLER M286 SWATH PASCAGOULA, MISSISSIPPI
139 RANCH ROAD SLIDELL, LOUISIANA 70460 PHONE NO: (985) 774-1955	FIELD CREW: R.I., E.K., J. M. & B. K. CALCULATED BY: R. IMPASTATO
SCALE: 1" = NONE	DATE: 7-18-09 7-26-09 SHEET NO.: 9



RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

SCALE: 1" = NONE

JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

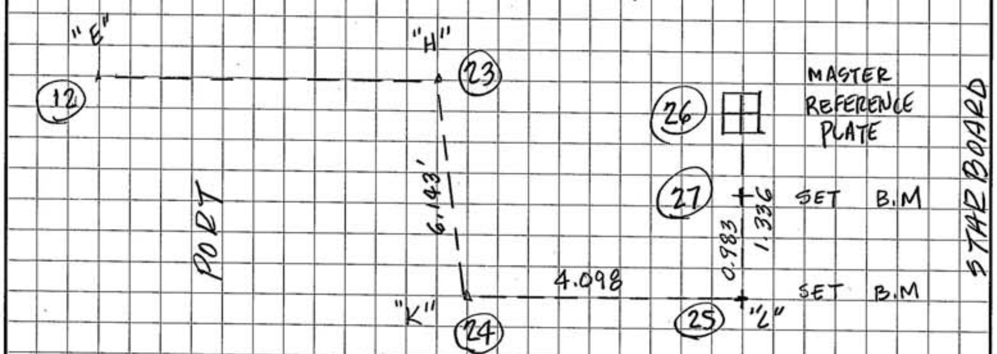
FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09
7-26-09

SHEET NO.: 10

MASTER REFERENCE PLATE ROOM



INST. ON PT "H" - B.S @ PT. "E"

∡1	∡2	AVG.	Z∡1	Z∡2	AVG.	DIST.	POINT
262°24'48"	262°24'50	262°24'49"	92°09'18"	267°50'37"	92°09'21"	6.143	"K"
INST. ON PT "K" - B.S. @ PT "H"							
103°10'42"	103°10'41"	103°10'42"	93°29'07"	266°30'33"	93°29'17"	4.098	"L" AFT B.M
INST. ON PT "L" - B.S @ PT "K"							
88°52'34	88°52'30'	88°52'32"	—	—	—	0.983	FWD. B.M
88°54'52"	88°54'48	88'54'50'	-	-	-	1.336	MRP

RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

SCALE: 1" = NONE

JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09 / 7-26-09 SHEET NO.: 11

STA	BS	HI	FS	ELEV	DESCRIPTION
				0.000	MASTER REFERENCE PLATE
	1.300	1.300			
			1.461	-0.161	FWD B.M -0.162
			1.461	-0.161	AFT B.M -0.162
			1.429	-0.129	PT "H" -0.130
			1.432	-0.132	T.P. 1
	1.467	1.335			
			0.440	0.895	T.P. 2
	0.414	1.309			
			0.392	0.917	T.P. 3 TOP OF RAIL
	-8.118	-7.201			
			1.357	-8.558	PT "B"
	1.352	-7.206			
			-8.122	0.916	T.P. 3
	0.365	1.281			
			0.387	0.894	T.P. 2
	0.429	1.323			
			1.456	-0.133	T.P. 1
	1.429	1.296			
			1.427	-0.131	PT "H"
			1.459	-0.163	AFT B.M.
			1.459	-0.163	FWD B.M.
			1.297	-0.001	M.R.P.

RAYMOND C. IMPASTATO
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JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09 7-26-09 SHEET NO.: 12

STA	BS	HI	FS	ELEV	DESCRIPTION
				0.917	T.P. 3 TOP OF RAIL
	0.427	1.344			
			-1.207	2.551	T.P. 4 EDGE OF DECK (BRIDGE WING)
	3.980	6.531			
			1.437	5.094	STBD B.M. TOP OF WHEEL HOUSE
			1.442	5.089	MID B.M. " " " "
			1.443	5.088	PORT B.M. " " " "
	1.387	6.475			
			1.386	5.089	MID B.M
			1.381	5.094	STBD. B.M
			3.923	2.552	T.P. 4
	-1.228	1.324			
			0.406	0.918	(0.001) T.P. 3

RAYMOND C. IMPASTATO
PROFESSIONAL
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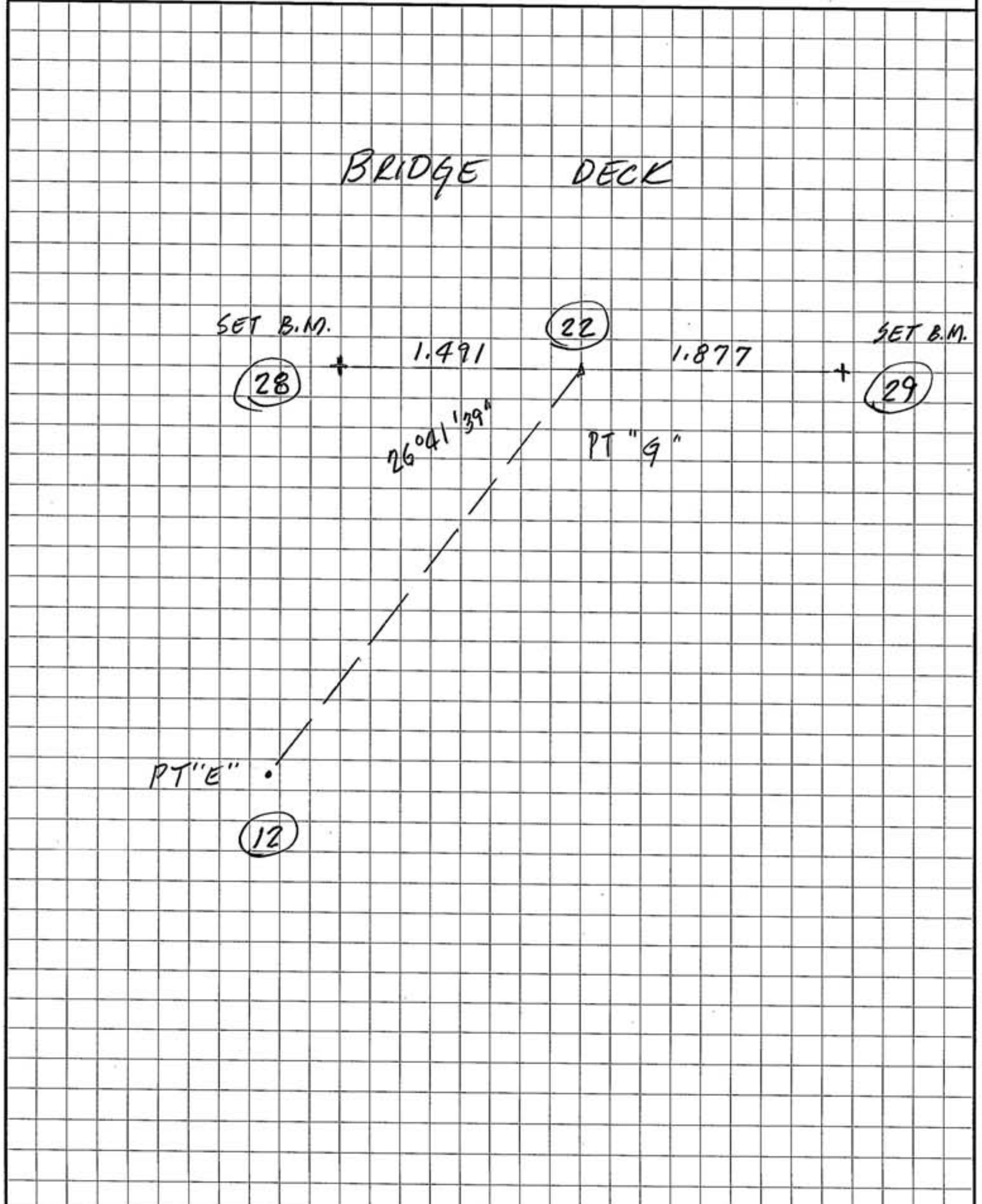
JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09 7-26-09 SHEET NO.: 13



RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

SCALE: 1" = NONE

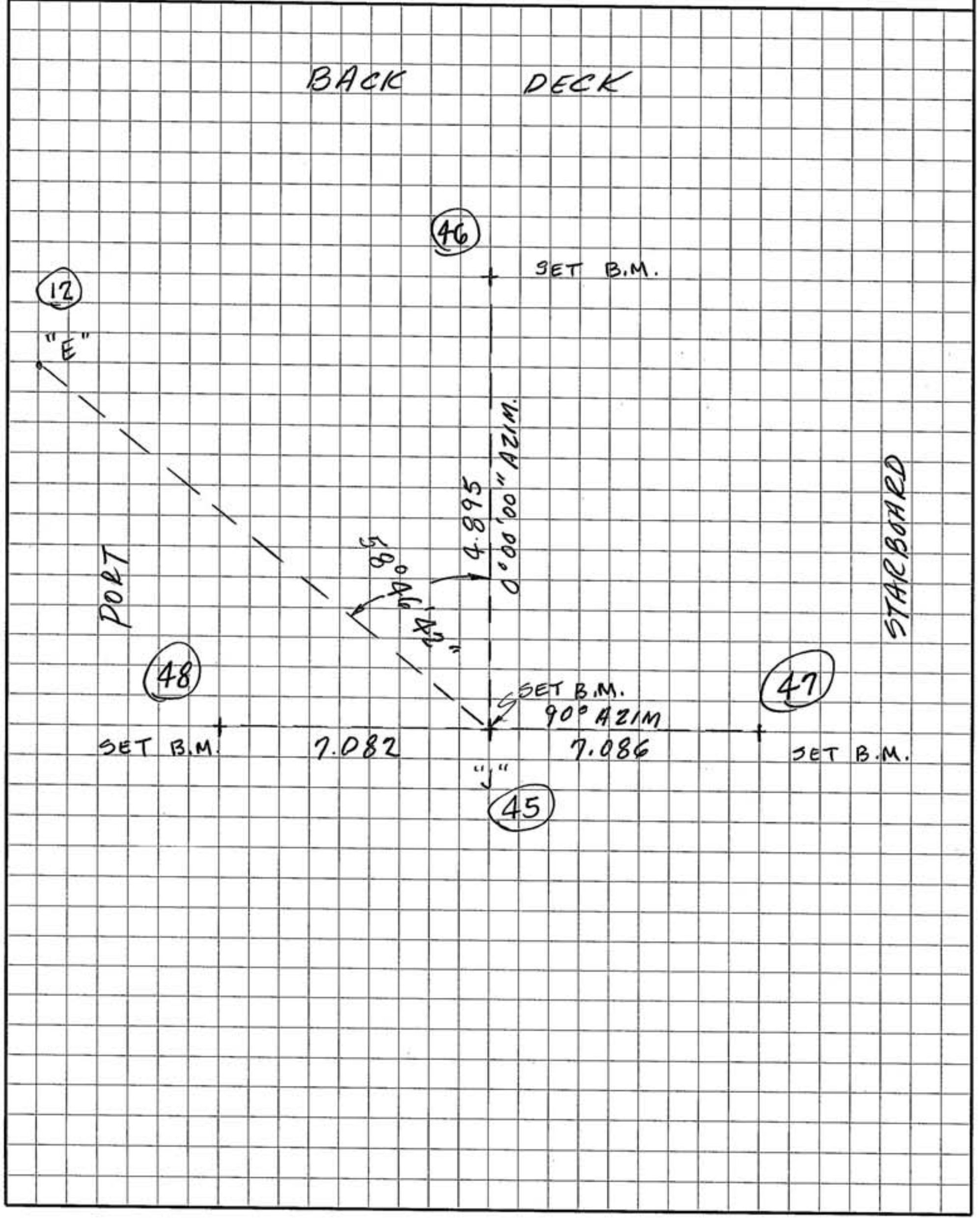
JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09
7-26-09

SHEET NO.: 14



RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

SCALE: 1" = NONE

JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09 7-26-09 SHEET NO.: 15

STA	BS	HI	FS	ELEV	DESCRIPTION
				2.551	T.P. 4 EDGE OF DECK (BRIDGE WING)
	1.385	3.936			
			1.445	2.491	STARBOARD B.M. BRIDGE WING (PORT SIDE)
			1.429	2.507	PORT B.M. (BRIDGE WING (PORT SIDE)
	1.411	3.918			
			1.427	2.491	STARBOARD B.M.
			1.367	2.551	T.P. 4
				0.000	MASTER REFERENCE PLATE
	1.344	1.344			
			1.375	-0.031	T. P. 5
	1.399	1.368			
			1.508	-0.140	FWD. B.M BACK DECK
			1.496	-0.128	AFT MID B.M. BACK DECK
			1.497	-0.129	STARBOARD B.M. BACK DECK
			1.492	-0.124	PORT B.M. BACK DECK
	1.466	1.342			
			1.471	-0.129	ST. B.M.
			1.470	-0.128	AFT MID B.M.
			1.482	-0.140	FWD. B.M.
			1.373	-0.031	T.P. 5
	1.383	1.352			
			1.352	0.000	MASTER REFERENCE PLATE

RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

SCALE: 1" = NONE

JOB: FERDINAND R. HASSLER

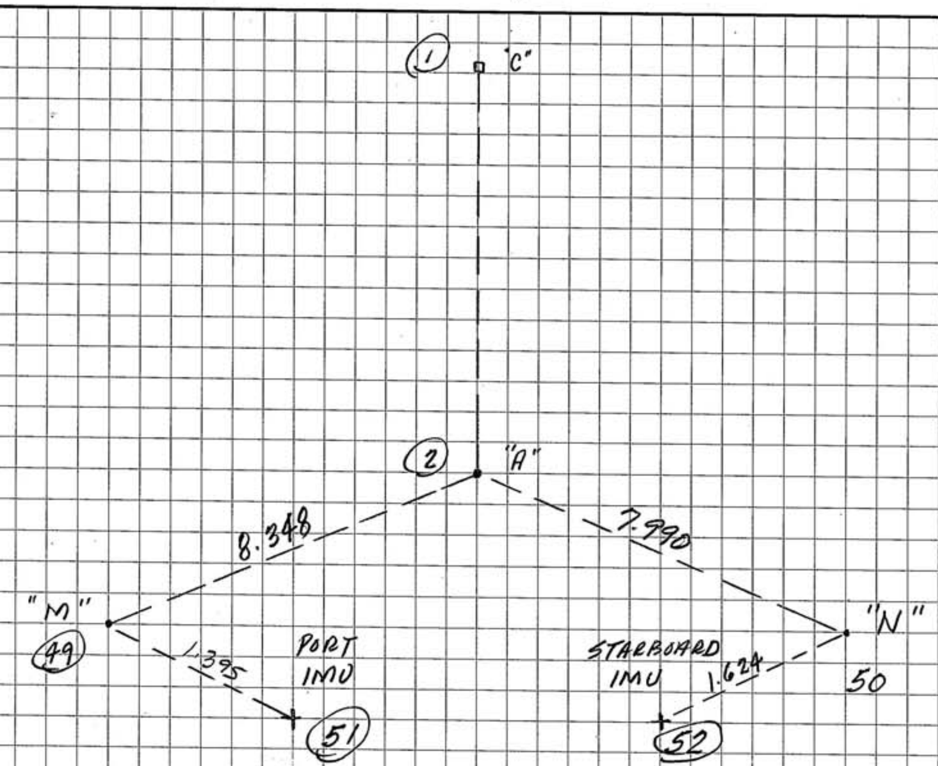
M286 SWATH

PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09 7-26-09 SHEET NO.: 16



INST ON PT "A" - B.S. @ PT "C"

∡ 1	∡ 2	AVG	Z∡ 1	Z∡ 2	AVG	DIST.	PT.
246°56'46	246°56'42"	246°56'44"	91°15'05	268°44'45	91°15'10"	8.348	"M"
110°36'30"	110°36'38"	110°36'34"	90°16'21"	269°43'51"	90°16'15"	7.990'	"N"

INST. ON PT. "M" - B.S. @ PT "A"

36°21'23"	36°21'27"	36°21'25"	91°19'18"	268°40'45"	91°19'17"	1.395	IMU PORT

INST. ON PT "N" - B.S. @ PT "A"

317°19'00	317°18'54"	317°18'57"	96°08'50"	263°50'58"	96°08'56"	1.624	IMU STARBORD

RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

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JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

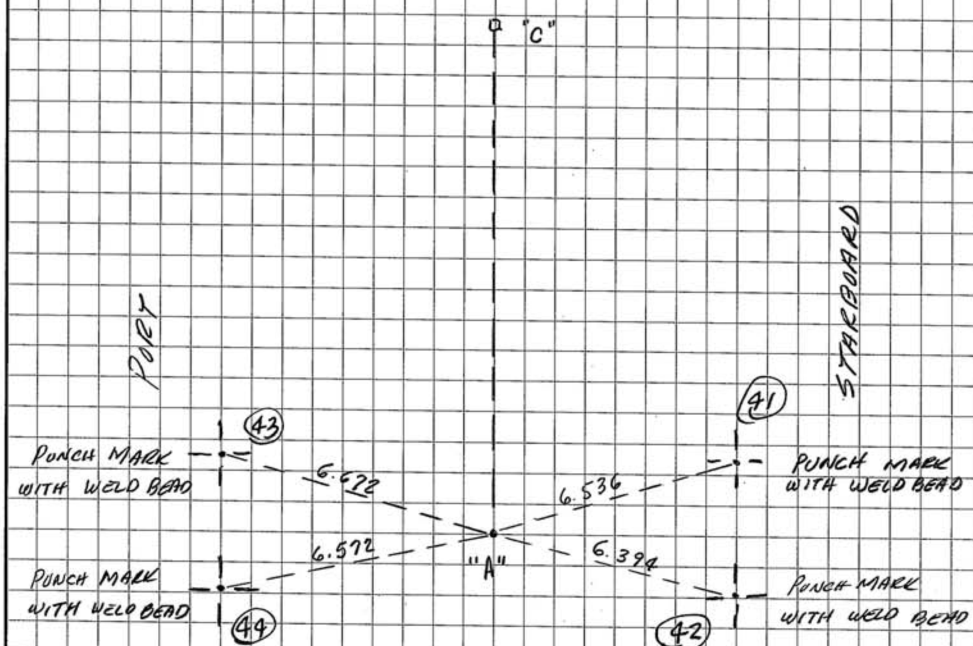
FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09 7-26-09 SHEET NO.: 17

STA	BS	HI	FS	ELEV	DESCRIPTION
				-8.558	PT "B"
	1.092	-7.466			
			-0.357	-7.109	T.P. 6 PORT SIDE
	-0.349	-7.458			
			1.100	-8.558	PT "B"
	1.100	-7.458			
			-0.361	-7.097	T. P. 7 STARBOARD SIDE
	-0.346	7.443			
			1.116	-8.559	(0.001) PT "B"
				-7.097	T.P. 7
	1.377	-5.720			
			0.104	-5.824	IMU STARBOARD (OLD)
	0.103	-5.721			
			1.376	-7.097	T.P. 7
				-7.109	T.P. 6
	1.341	-5.768			
			0.070	-5.838	IMU PORT (OLD)
	0.087	-5.751			
			1.358	-7.109	T. P. 6

RAYMOND C. IMPASTATO PROFESSIONAL LAND SURVEYOR 139 RANCH ROAD SLIDELL, LOUISIANA 70460 PHONE NO: (985) 774-1955 SCALE: 1" = NONE	JOB: FERDINAND R. HASSLER M286 SWATH PASCAGOULA, MISSISSIPPI FIELD CREW: R.I., E.K., J. M. & B. K. CALCULATED BY: R. IMPASTATO DATE: 7-18-09 7-26-09 SHEET NO.: 18



INSTRUMENT OF PT "A" - B.S. @ PT "C"

∡1	∡2	AVG.	Z∡1	Z∡2	AVG	DIST.	POINT
76°51'22"	76°51'28"	76°51'25"	89°41'15"	270°18'38"	89°41'19"	6.536	41
85°40'36"	85°40'32"	85°40'34"	89°44'20"	270°15'48"	89°44'16"	6.394	42
279°43'20"	279°43'21"	279°43'21"	89°58'54"	270°00'50"	89°59'02"	6.672	43
272°26'53"	272°27'01"	272°26'57"	90°00'48"	269°59'21"	90°00'43"	6.572	44

RAYMOND C. IMPASTATO
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JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I., E.K., J. M. & B. K.

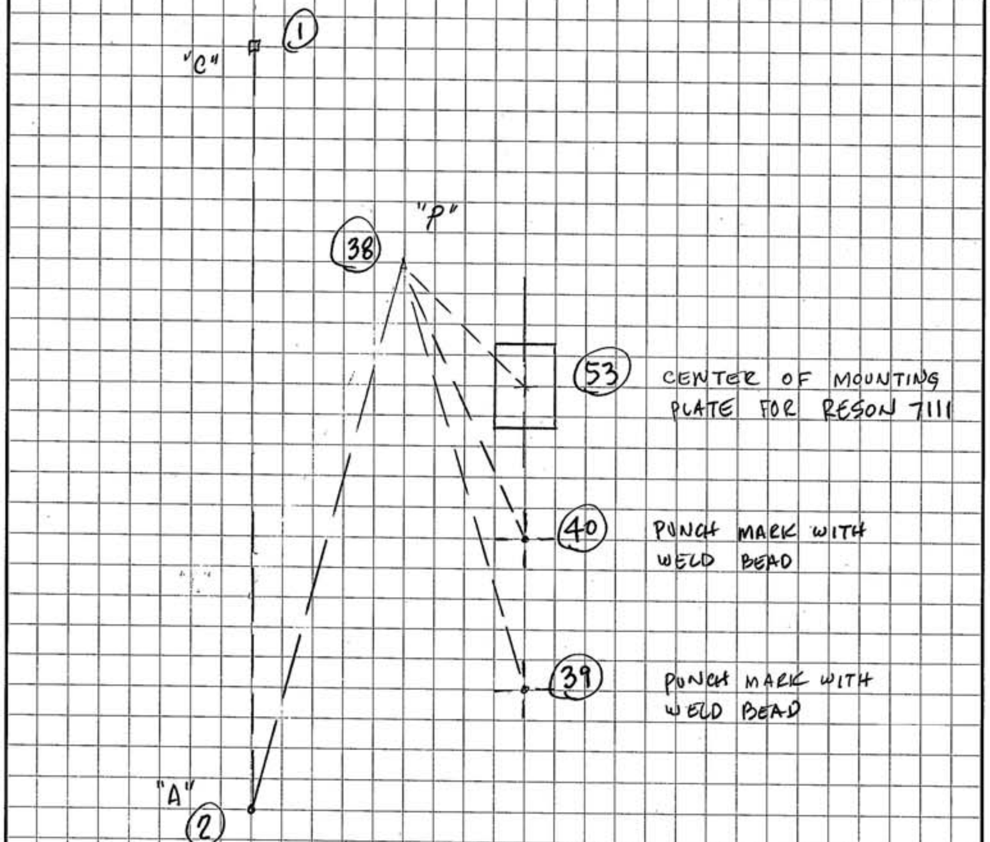
CALCULATED BY: R. IMPASTATO

DATE: 7-18-09
7-26-09

SHEET NO.: 19

INST ON PT "A" - BS @ PT "C"

∡1	∡2	AVG	Z∡1	Z∡2	AVG	DIST.	POINT
19°03'19	19°03'21"	19°03'20"	92°05'28"	267°54'30	92°05'28	10.455	"P"

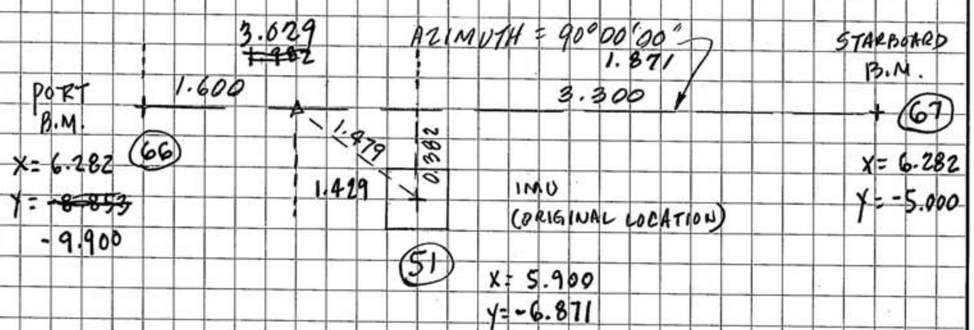


INST ON PT "P" - B.S. @ PT. "A"

∡1	∡2	AVG	Z∡1	Z∡2	AVG.	DIST	POINT
274°14'00"	274°13'51"	274°13'56"	82°48'55"	277°11'02"	82°48'57"	3.947	RESON 7111
291°24'44"	291°24'49"	291°24'46"	83°00'01"	276°59'44"	83°00'09"	4.820	PUNCH MARK
297°48'51"	297°49'01"	297°48'56"	84°29'45	275°30'01"	84°29'52"	5.363	PUNCH MARK

RAYMOND C. IMPASTATO PROFESSIONAL LAND SURVEYOR	JOB: FERDINAND R. HASSLER M286 SWATH PASCAGOULA, MISSISSIPPI
139 RANCH ROAD SLIDELL, LOUISIANA 70460 PHONE NO: (985) 774-1955	FIELD CREW: R.I., E.K., J. M. & B. K. CALCULATED BY: R. IMPASTATO
SCALE: 1" = NONE	DATE: 7-18-09 7-26-09 SHEET NO.: 20

BENCH MARKS IMU ROOM
PORT SIDE PONTOON



RAYMOND C. IMPASTATO
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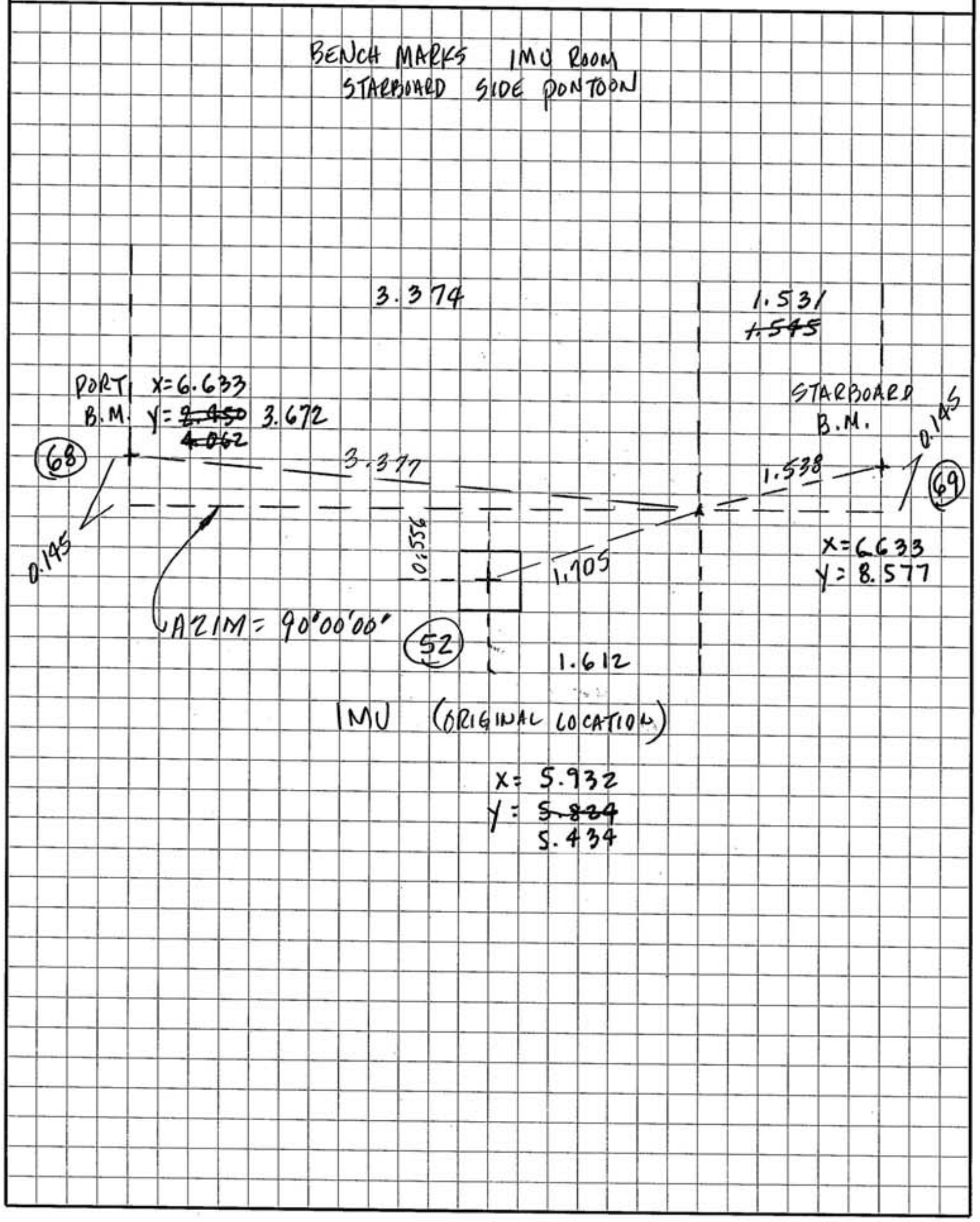
FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09 7-26-09 SHEET NO.: 21



RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

SCALE: 1" = NONE

JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I., E.K., J. M. & B. K.

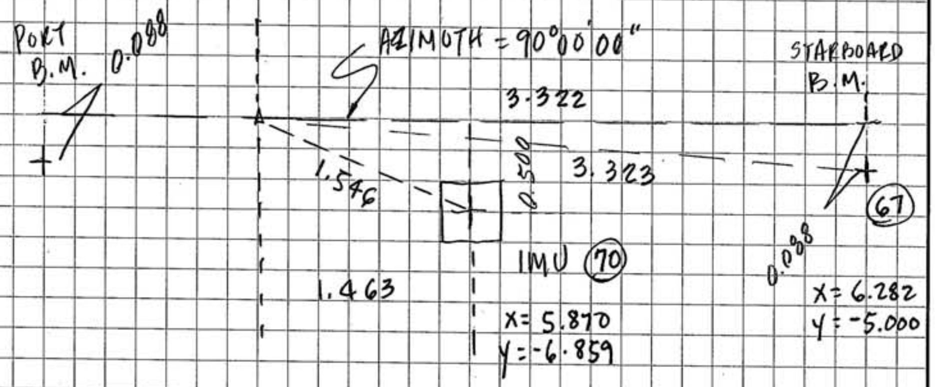
CALCULATED BY: R. IMPASTATO

DATE: 7-18-09 7-26-09 SHEET NO.: 22

STA	BS	HI	FS	ELEV	DESCRIPTION
					(ORIGINAL LOCATION)
				-5.838	IMU PORT SIDE PONTOON
	0.268	-5.570			
			0.220	-5.790	PORT B.M.
			0.289	-5.859	STARBOARD B.M
	0.296	-5.560			
			0.227	-5.790	PORT B.M.
			0.275	-5.838	IMU
					(ORIGINAL LOCATION)
				-5.824	IMU STARBOARD SIDE B.M.
	0.227	-5.597			
			0.250	-5.847	PORT B.M
			0.200	-5.797	STARBOARD B.M.
	0.215	-5.582			
			0.266	-5.848	PORT B.M.
			0.242	-5.824	IMU

RAYMOND C. IMPASTATO PROFESSIONAL LAND SURVEYOR	JOB: FERDINAND R. HASSLER M286 SWATH PASCAGOULA, MISSISSIPPI
139 RANCH ROAD SLIDELL, LOUISIANA 70460 PHONE NO: (985) 774-1955	FIELD CREW: R.I., E.K., J. M. & B. K. CALCULATED BY: R. IMPASTATO
SCALE: 1" = NONE	DATE: 7-18-09 7-26-09 SHEET NO.: 23

PRESENT LOCATION OF IMU
PORT SIDE PONTOON



RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

SCALE: 1" = NONE

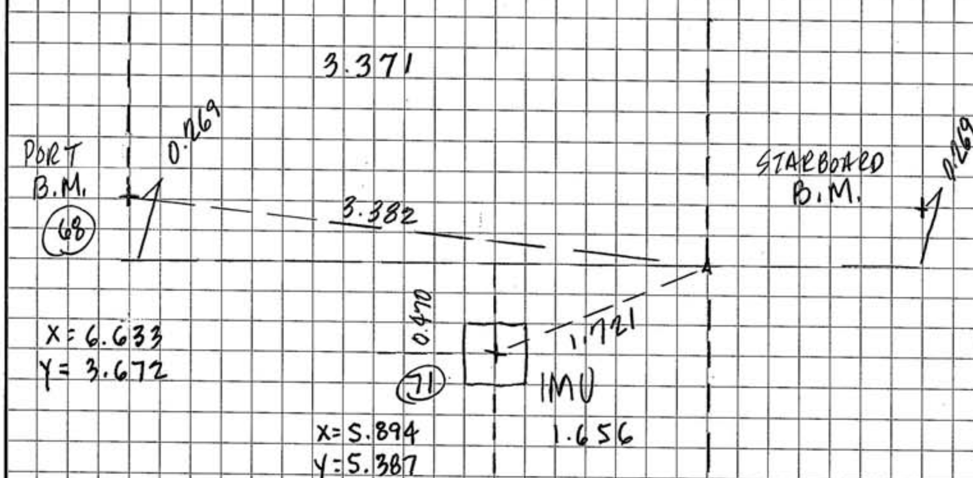
JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09 7-26-09 SHEET NO.: 24

PRESENT LOCATION OF IMU
STARBOARD SIDE PONTOON



RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

SCALE: 1" = NONE

JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09 7-26-09 SHEET NO.: 25

STA	BS	HI	FS	ELEV	DESCRIPTION
					PRESENT LOCATION PORT SIDE PONTOON IMU
				-5.859	STARBOARD B.M.
	0.184	-5.675			
			0.091	-5.766	IMU
	0.103	-5.663			
			0.196	-5.859	STARBOARD B.M
					PRESENT LOCATION STARBOARD SIDE PONTOON IMU
				-5.847	PORT B.M.
	0.236	-5.611			
			0.142	-5.753	IMU
	0.158	-5.595			
			0.252	-5.847	PORT B.M.

RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

SCALE: 1" = NONE

JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

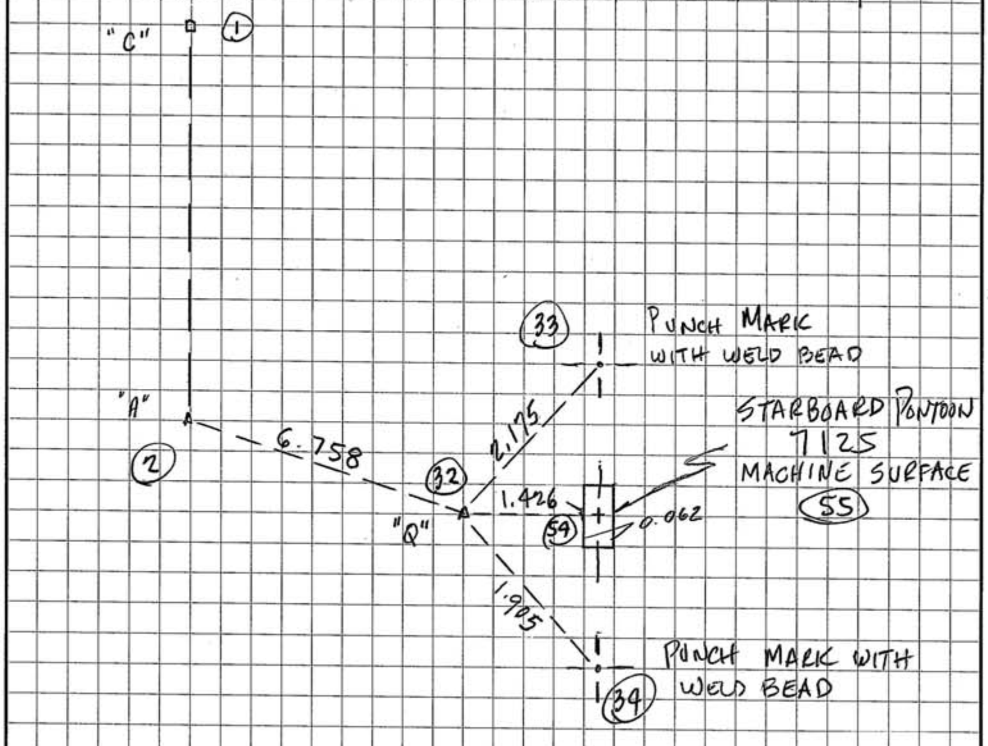
FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09
7-26-09
SHEET NO.: 26

INST. ON PT. "A" - B.S. @ PT "C"

∡1	∡2	AVG	Z∡1	Z∡2	AVG.	DIST	POINT
117°20'06"	117°20'10"	117°20'08	90°54'43"	269°05'11"	90°54'46"	6.758	"Q"



INST. ON PT. "Q" - B.S. @ PT. "A"

∡1	∡2	AVG	Z∡1	Z∡2	AVG	DIST	POINT
150°50'00"	150°50'18"	150°50'09	68°11'10"	291°48'44"	68°11'13"	1.426	PORT SIDE OF 7125
103°03'47"	103°04'00"	103°03'54"	77°48'15"	282°11'54	77°48'11"	2.175	PUNCH MARK
192°58'26"	192°58'41"	192°58'34"	76°10'56"	283°49'00"	76°10'58	1.905	PUNCH MARK

RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

SCALE: 1" = NONE

JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

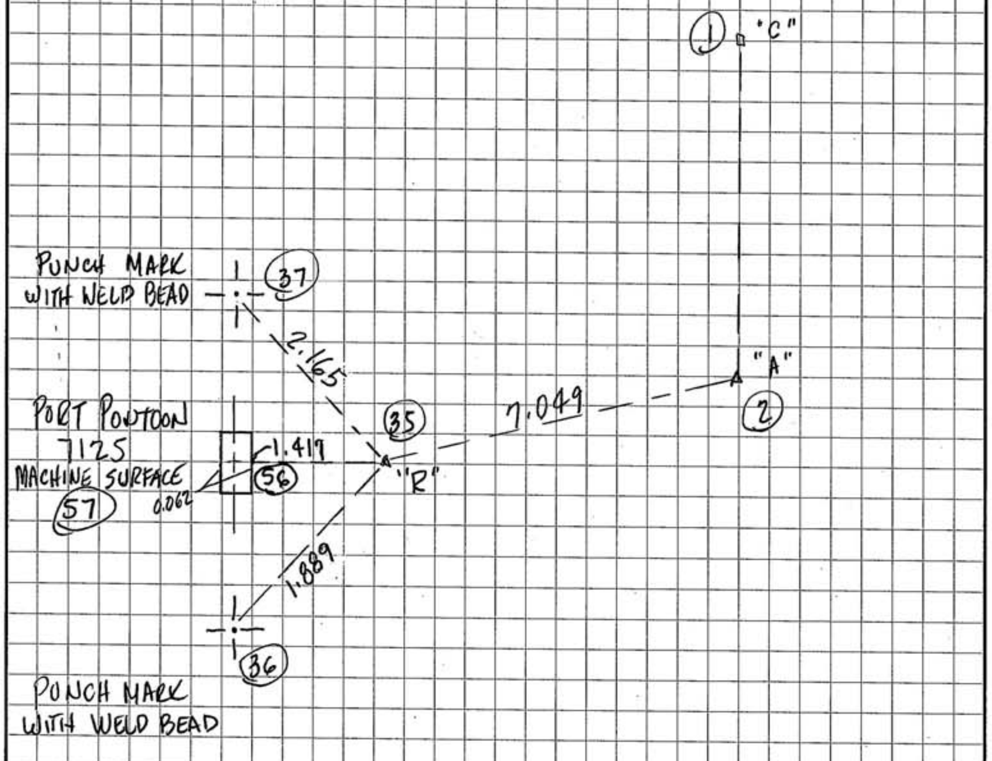
FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09 SHEET NO.: 27
7-26-09

INST. ON PT "A" - B.S. @ PT "C"

∡1	∡2	AVG	Z∡1	Z∡2	AVG	DIST	POINT
242°20'59	242°20'59"	242°20'59"	91°17'11"	268°42'49	91°17'11"	7.049	"R"



INST. ON PT "R" - B.S. @ PT "A"

∡1	∡2	AVG	Z∡1	Z∡2	AVG	DIST	POINT
207°41'09"	207°44'21"	207°44'15"	64°49'01"	295°10'23"	64°49'19"	1.417	STARB. SIDE 7125
256°06'39"	256°06'49"	256°06'44"	75°35'51"	284°23'58"	75°35'57"	2.165	PUNCH MARK
166°12'22"	166°12'21"	166°12'22"	73°41'25"	286°18'14"	73°41'36"	1.889	PUNCH MARK

RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

SCALE: 1" = NONE

JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09 7-26-09 SHEET NO.: 28

STA	BS	HI	FS	ELEV	DESCRIPTION
				-8.558	PT "B"
	1.234	-7.324			
			-0.166	-7.158	AFT P.M. 7125 PORT PONTOON
			-0.239	-7.085	7125 PORT SIDE " "
			-0.242	-7.082	7125 STARB. SIDE " "
			-0.174	-7.150	FWD P.M. 7125 " "
			-0.158	-7.166	AFT P.M. (-7.167) " "
			-0.157	-7.167	FWD P.M (-7.168) " "
			-0.494	-6.830	RESON 7111 STARBOARD PONTOON
			-0.586	-6.738	FWD. P.M. 7111 " "
			-0.513	-6.811	AFT P.M. 7111 " "
			-0.179	-7.145	FWD P.M FB " "
			-0.175	-7.149	AFT P.M. FB " "
			-0.178	-7.146	FWD P.M. 7125 " "
			-0.247	-7.077	7125 PORT SIDE " "
			-0.251	-7.073	7125 STARB. SIDE " "
			-0.172	-7.152	AFT P.M. 7125 " "
	-0.186	-7.330			
			-0.265	-7.073	7125 STARB. SIDE " "
			-0.261	-7.077	7125 PORT SIDE " "
			-0.191	-7.147	FWD P.M 7125 " "
			-0.188	-7.150	AFT P.M. FB " "
			-0.192	-7.146	FWD P.M. FB " "
			-0.526	-6.812	AFT P.M. 7111 " "
			-0.600	-6.738	FWD P.M. 7111 " "
			-0.507	-6.831	RESON 7111 " "
			-0.169	-7.169	FWD P.M. FB PORT PONTOON
			-0.170	-7.168	AFT P.M. FB " "
			-0.187	-7.151	FWD P.M. 7125 " "
			-0.256	-7.082	7125 STARB. SIDE " "
			-0.252	-7.086	7125 PORT SIDE " "
			-0.179	-7.159	AFT P.M. 7125 " "
			1.220	-8558	PT "B"

RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

SCALE: 1" = NONE

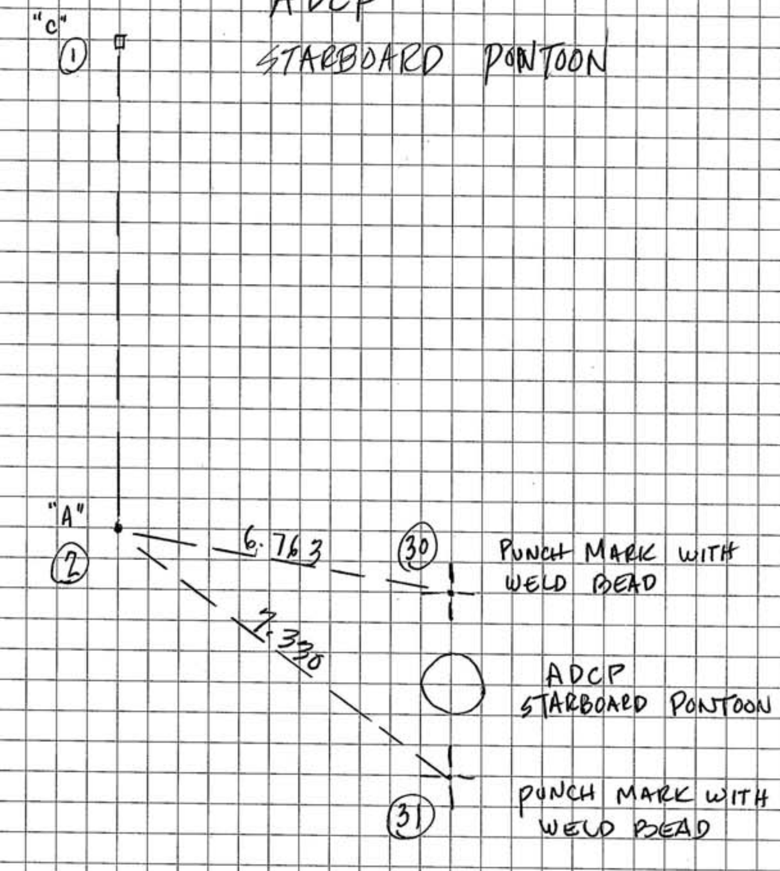
JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09 7-26-09 SHEET NO.: 29

ADCP
STARBOARD PONTOON



∡1	∡2	AVG	Z∡1	Z∡2	AVG	DIST	POINT
109°11'49"	109°11'57"	109°11'53"	87°03'07"	272°56'52"	87°03'07"	6.763	FWD PUNCH MARK
119°11'11"	119°11'14"	119°11'13"	87°20'24"	272°39'40"	87°20'22"	7.336	AFT PUNCH MARK

RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

SCALE: 1" = **NONE**

JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09 7-26-09 SHEET NO.: 38

STA	BS	HI	FS	ELEV	DESCRIPTION
				-7.152	AFT P.M. 7125 STARBOARD PONTOON
	0.279	-6.873			
			0.256	-7.129	AFT PUNCH MARK ADCP
			0.263	-7.136	FWD PUNCH MARK ADCP
	0.297	-6.839			
			0.290	-7.129	AFT PUNCH MARK ADCP
			0.313	-7.152	AFT P.M. 7125 STARBOARD PONTOON

RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

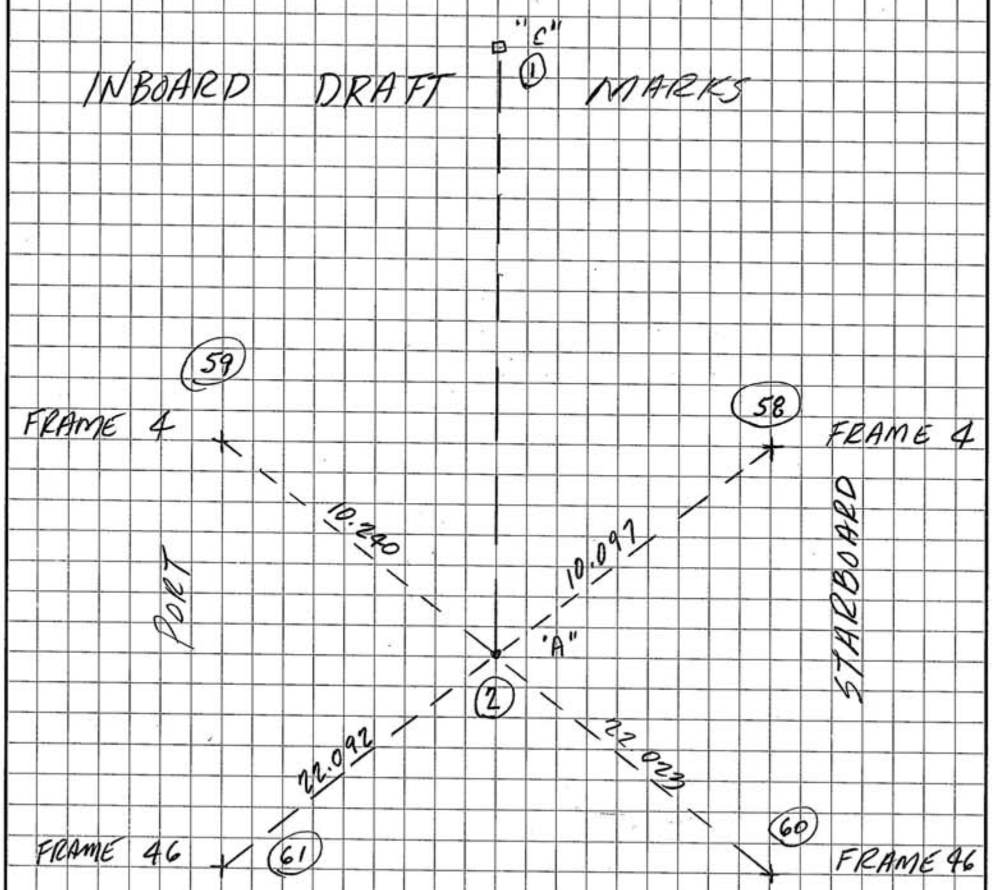
SCALE: 1" = NONE

JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09 7-26-09 SHEET NO.: 31



INST. ON PT "A" - B.S. @ PT "C"

∡1	∡2	AVG	Z∡1	Z∡2	AVG	DIST	POINT
41°11'21"	41°11'05"	41°11'13"	61°42'40"	298°17'23"	61°42'39"	10.097	FRAME 4
316°12'03"	316°12'10"	316°12'07"	62°15'00	297°45'04	62°14'58	10.240	FRAME 4
162°46'43	162°46'44"	162°46'44"	77°38'18"	282°21'40"	77°38'19"	22.023	FRAME 46
196°29'33"	196°29'37"	196°29'30"	77°38'32"	282°21'26"	77°38'33"	22.092	FRAME 46

RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

SCALE: 1" = NONE

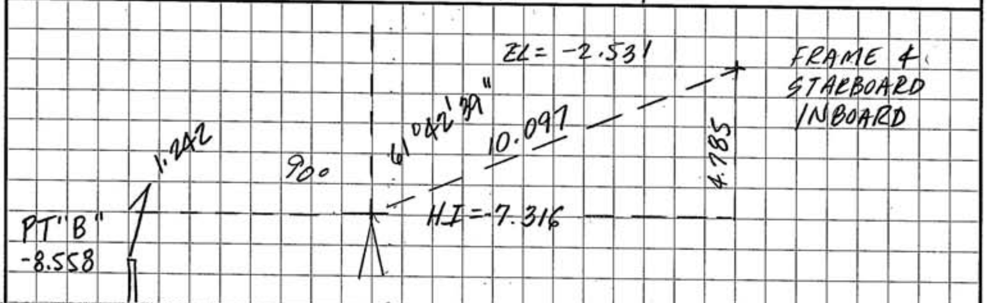
JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

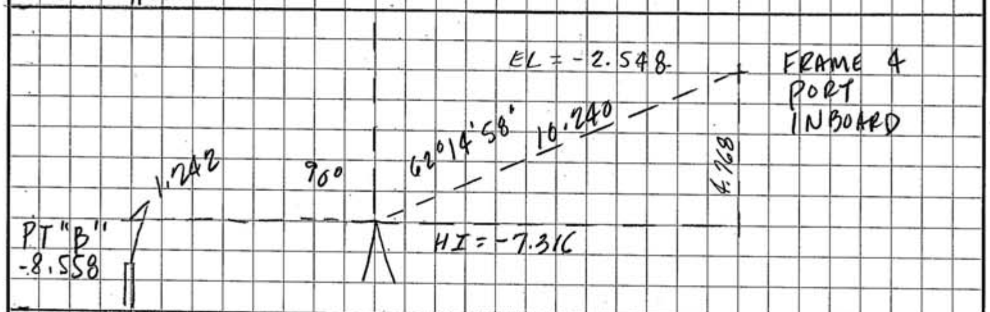
FIELD CREW: R.I., E.K., J. M. & B. K.

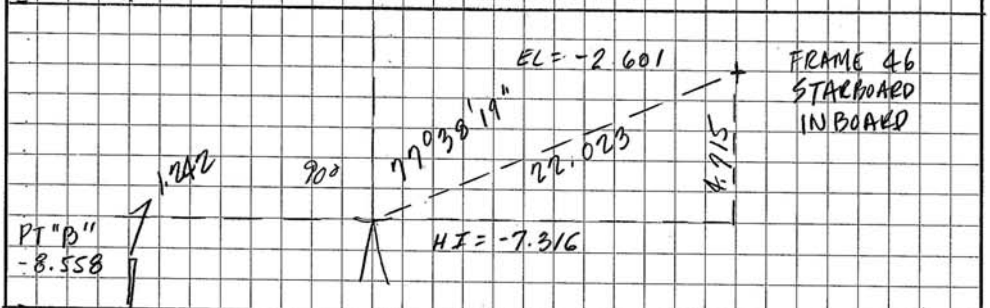
CALCULATED BY: R. IMPASTATO

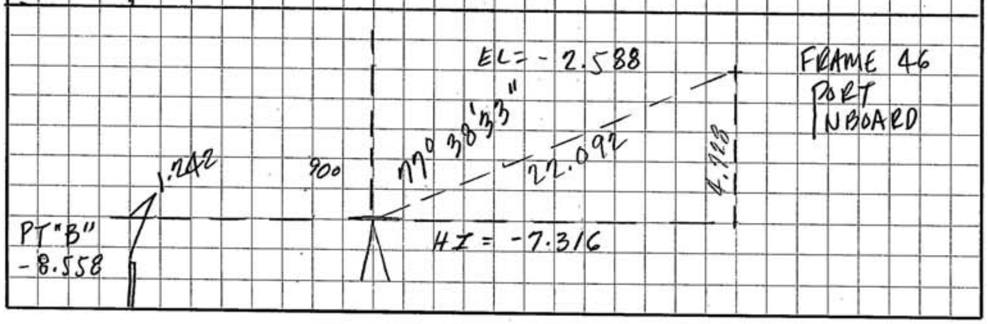
DATE: 7-18-09
7-26-09

SHEET NO.: 32









RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

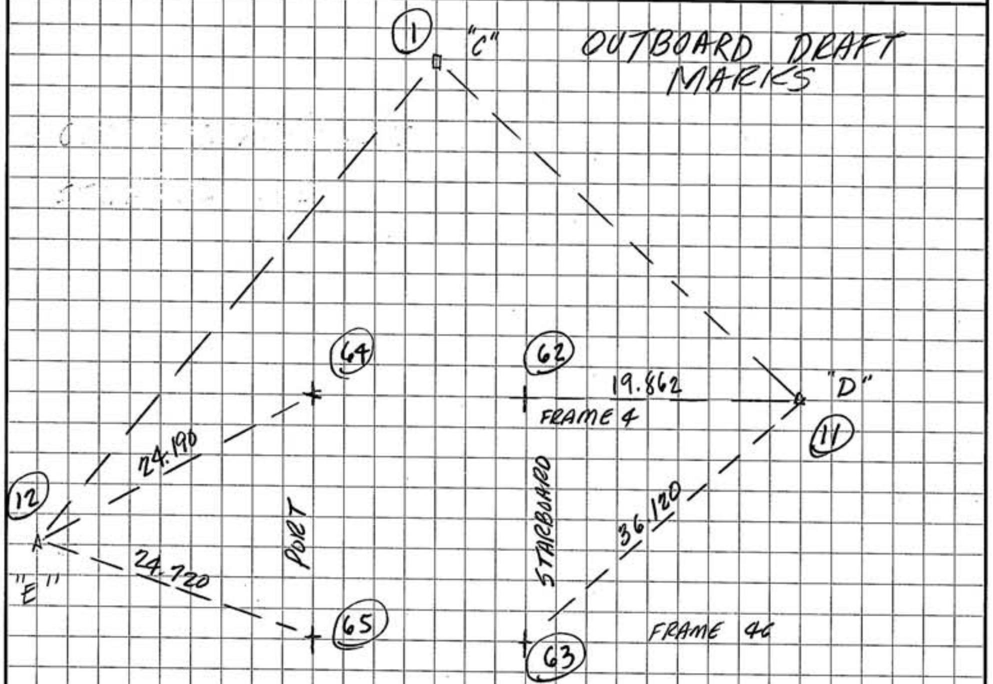
SCALE: 1" = NONE

JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09 / 7-26-09 SHEET NO.: 33



INSTRUMENT ON PT "D" - B.S @ PT "C"

∡1	∡2	AVG	Z∡1	Z∡2	AVG	DIST	POINT
292°15'44	292°15'53"	292°15'49"	76°11'28"	283°48'34'	76°11'27"	19.862	FRAME 4 STARBOARD
243°35'26"	243°35'34"	243°35'30"	82°33'53"	277°26'07"	82°33'53"	36.126	FRAME 46 STARBOARD
		INST. @ PT "E" - B.S. @ PT "C"					
30°38'48"	30°38'49"	30°38'49"	101°49'55"	258°10'01"	101°49'57"	24.145	FRAME 4 PORT
100°00'48"	100°00'49	100°00'49	101°37'22"	258°22'42"	101°37'20"	24.720	FRAME 46 PORT

RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

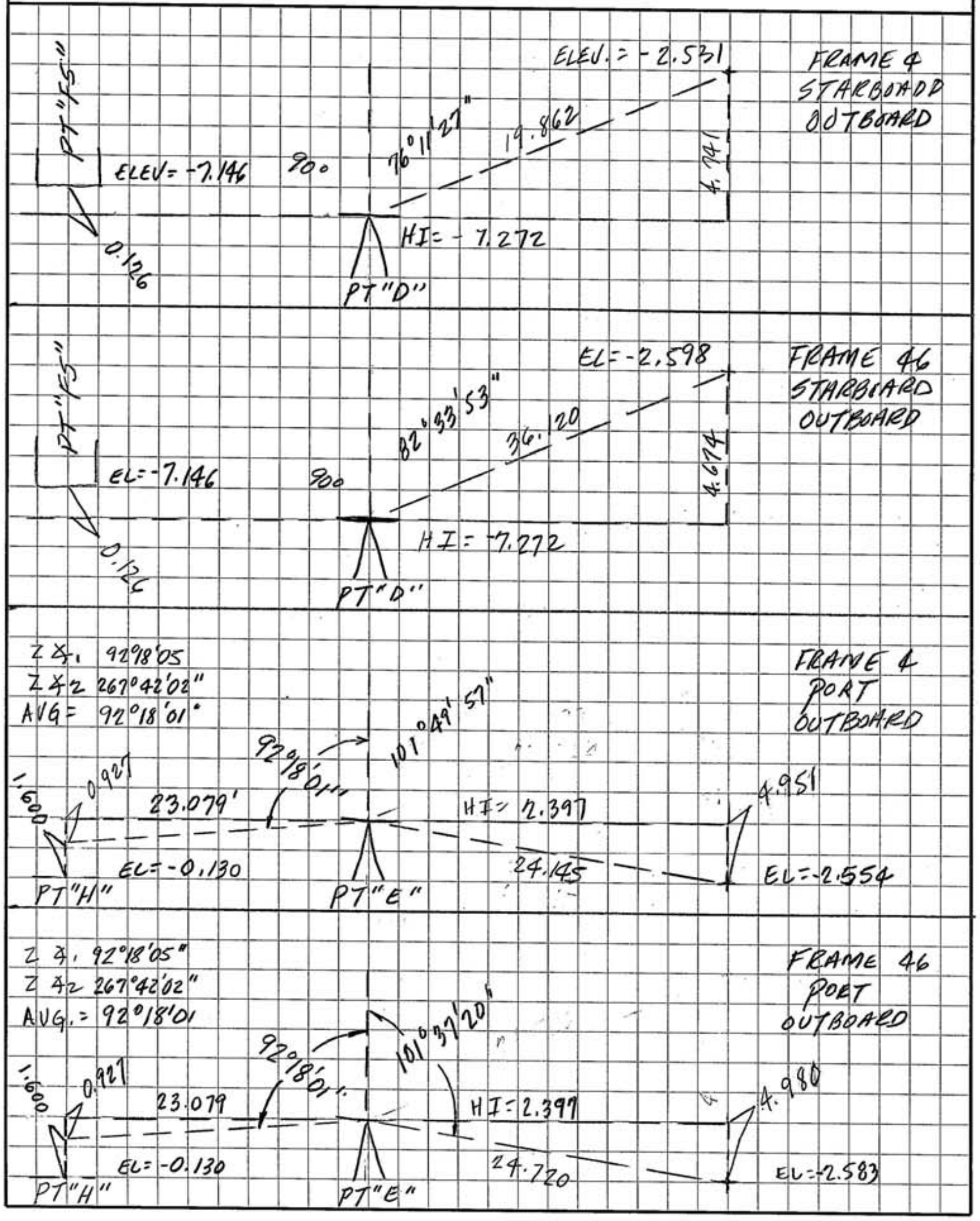
SCALE: 1" = NONE

JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I., E.K., J. M. & B. K.

CALCULATED BY: R. IMPASTATO

DATE: 7-18-09 / 7-26-09 SHEET NO.: 34



RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

SCALE: 1" = **NONE**

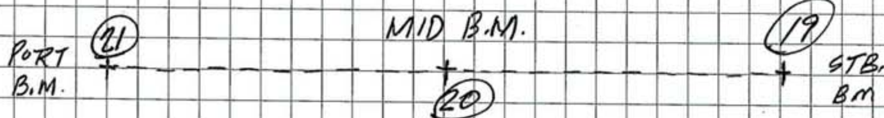
JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I. & E.K.

CALCULATED BY: R. IMPASTATO

DATE: 11-4-09 SHEET NO.: 1

TOP OF WHEEL HOUSE



INSTRUMENT ON STB. B.M - B.S @ PORT B.M. ZA = 103°44'50"

	HOR. ∡	AZIMUTH
BOLT ℄ LOWER GPS ANTENNAE	310° 52' 34"	
	310° 52' 42"	
AVG	310° 52' 38"	220° 52' 38
BOLT ℄ UPPER GPS ANTENNAE	307° 14' 02"	
	307° 14 23	
AVG	307° 14' 13"	217° 14' 13"

INSTRUMENT ON MID B.M. - B.S @ PORT B.M. ZA = 115° 58' 30"

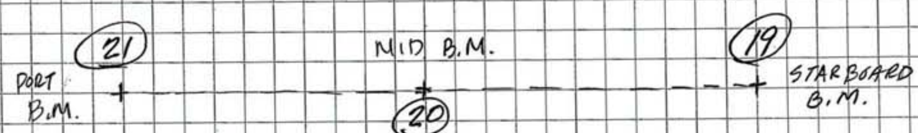
	HORIZ ∡	AZIMUTH	ZENITH ∡
BOLT ℄ LOWER GPS ANTENNAE	283° 53' 38"		77° 53' 50"
	283° 53' 48"		282° 06' 40"
AVG	283° 53' 43	193° 53' 43"	77° 53' 35"
BOLT ℄ UPPER GPS ANTENNAE	282° 18' 38"		62° 31' 34"
	282° 18' 40"		297° 28' 25"
AVG	282° 18' 39	192° 18' 39"	62° 31' 35"

PORT GPS
ANTENNAES

NOTE: 0.022m FROM
BOTTOM OF BOLT TO BOTTOM
OF ANTENNAE

RAYMOND C. IMPASTATO PROFESSIONAL LAND SURVEYOR 139 RANCH ROAD SLIDELL, LOUISIANA 70460 PHONE NO: (985) 774-1955 SCALE: 1" = **NONE**	JOB: FERDINAND R. HASSLER M286 SWATH PASCAGOULA, MISSISSIPPI FIELD CREW: R.I. & E.K. CALCULATED BY: R. IMPASTATO DATE: 11-4-09 SHEET NO.: 2

TOP OF WHEEL HOUSE



INSTRUMENT ON PORT B.M. - B.S. @ STARBOARD B.M.

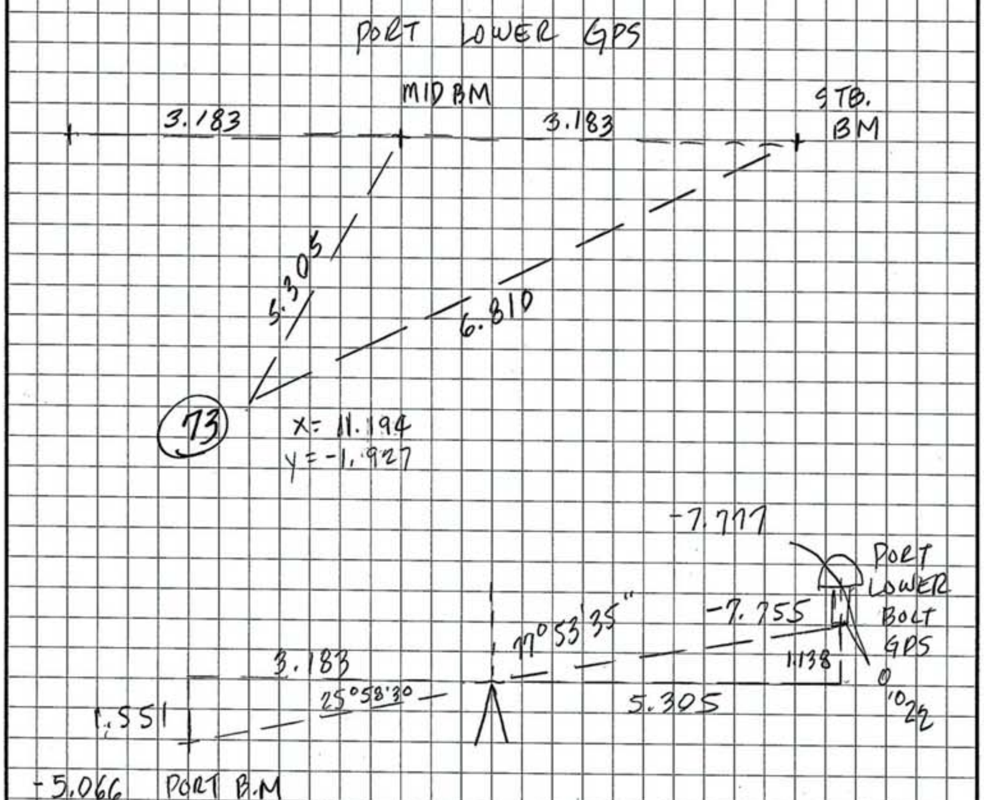
	HORIZ ∡	AZIMUTH
BOLT ℄ LOWER GPS ANTENNAE	49°34'47"	
	49°34'43"	
AVG.	49°34'45"	139°34'45
BOLT ℄ UPPER GPS ANTENNAE	53°24'46"	
	53°24'50"	
AVG.	53°24'48"	143°24'48

INSTRUMENT ON MID B.M. B.S @ PORT B.M. Z. A = 115°58'30"

	HORIZ. ∡	AZIMUTH	ZENITH ∡
BOLT ℄ LOWER GPS ANTENNAE	256°41'23"		77°46'38"
	256°41'18"		282°14'00"
AVG	256°41'21"	166°41'21"	77°46'19"
	258°30'00"		62°24'45"
BOLT ℄ UPPER GPS ANTENNAE	258°29'42"		297°35'00"
AVG.	258°29'51"	168°29'51"	62°24'53"

STARBOARD GPS
ANTENNAES

RAYMOND C. IMPASTATO PROFESSIONAL LAND SURVEYOR	JOB: FERDINAND R. HASSLER M286 SWATH PASCAGOULA, MISSISSIPPI
139 RANCH ROAD SLIDELL, LOUISIANA 70460 PHONE NO: (985) 774-1955	FIELD CREW: R.I. & E.K. CALCULATED BY: R. IMPASTATO
SCALE: 1" = **NONE**	DATE: 11-4-09 SHEET NO.: 3



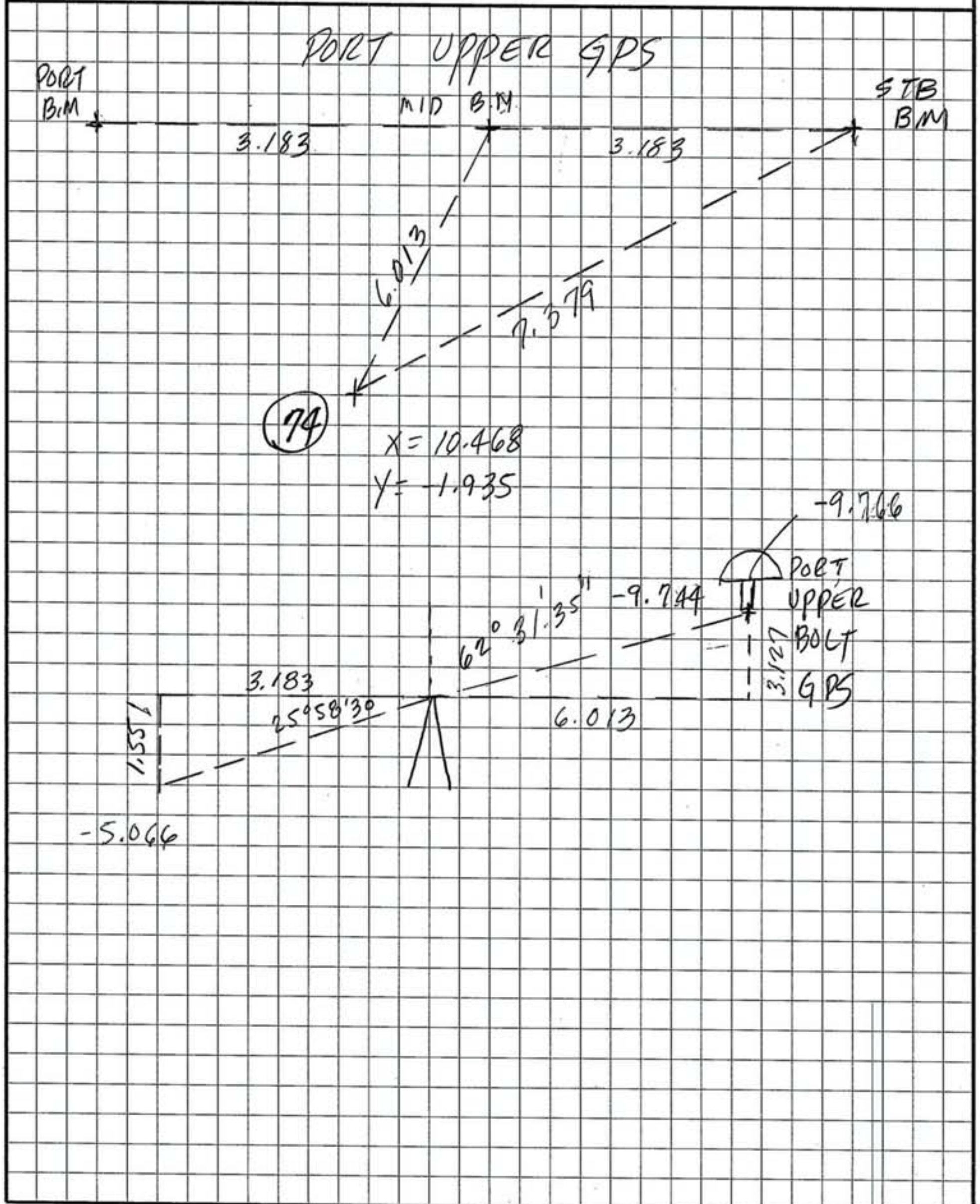
RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

SCALE: 1" = **NONE**

JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I. & E.K.
CALCULATED BY: R. IMPASTATO
DATE: 11-4-09 SHEET NO.: 4



RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

SCALE: 1" = **NONE**

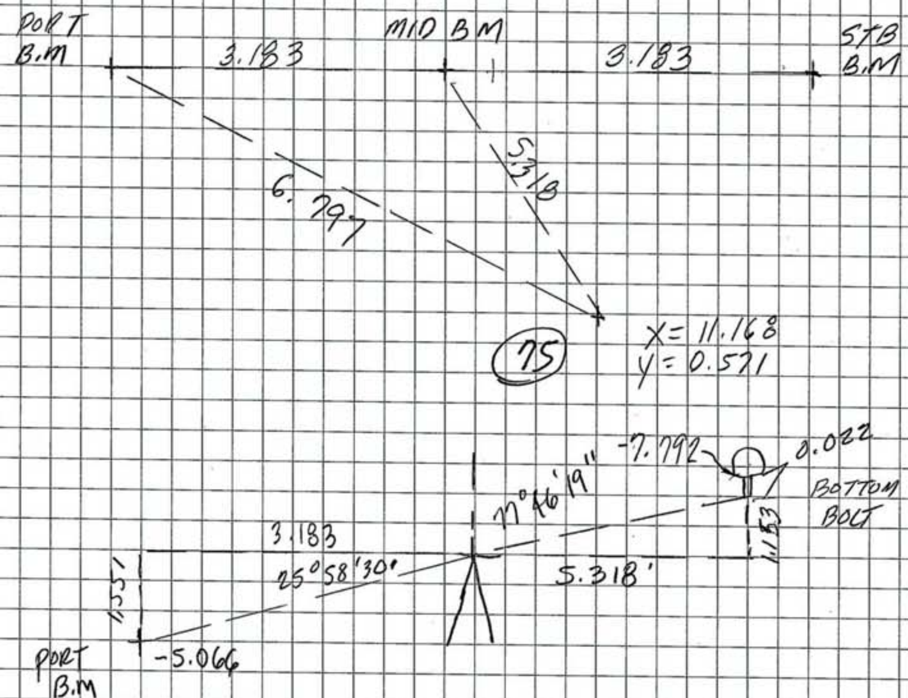
JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I. & E.K.

CALCULATED BY: R. IMPASTATO

DATE: 11-4-09 SHEET NO.: 5

STARBOARD LOWER GPS



RAYMOND C. IMPASTATO
PROFESSIONAL
LAND SURVEYOR

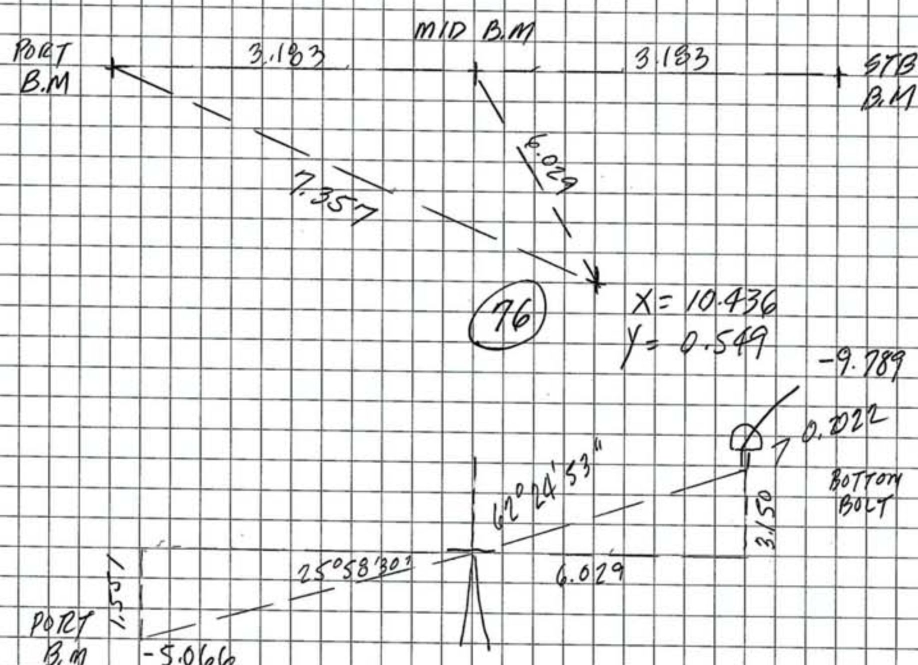
139 RANCH ROAD
SLIDELL, LOUISIANA 70460
PHONE NO: (985) 774-1955

SCALE: 1" = **NONE**

JOB: FERDINAND R. HASSLER
M286 SWATH
PASCAGOULA, MISSISSIPPI

FIELD CREW: R.I. & E.K.
CALCULATED BY: R. IMPASTATO
DATE: 11-4-09 SHEET NO.: 6

STARBOARD UPPER GPS



RAYMOND C. IMPASTATO PROFESSIONAL LAND SURVEYOR 139 RANCH ROAD SLIDELL, LOUISIANA 70460 PHONE NO: (985) 774-1955 SCALE: 1" = **NONE**	JOB: FERDINAND R. HASSLER M286 SWATH PASCAGOULA, MISSISSIPPI FIELD CREW: R.I. & E.K. CALCULATED BY: R. IMPASTATO DATE: 11-4-09 SHEET NO.: 7

BACK DECK

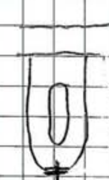
INSTRUMENT ON STARBOARD B.M. B.S. @ PORT B.M.
Z.A = 96°53'06"

	HORIZ. ∠	AZIMUTH	ZENITH ∠
℄ BOTTOM OF CENTER BLOCK	318°17'00"		73°49'25"
	318°16'48"		286°10'30"
AVG	318°16'54"	228°16'54"	73°49'28"

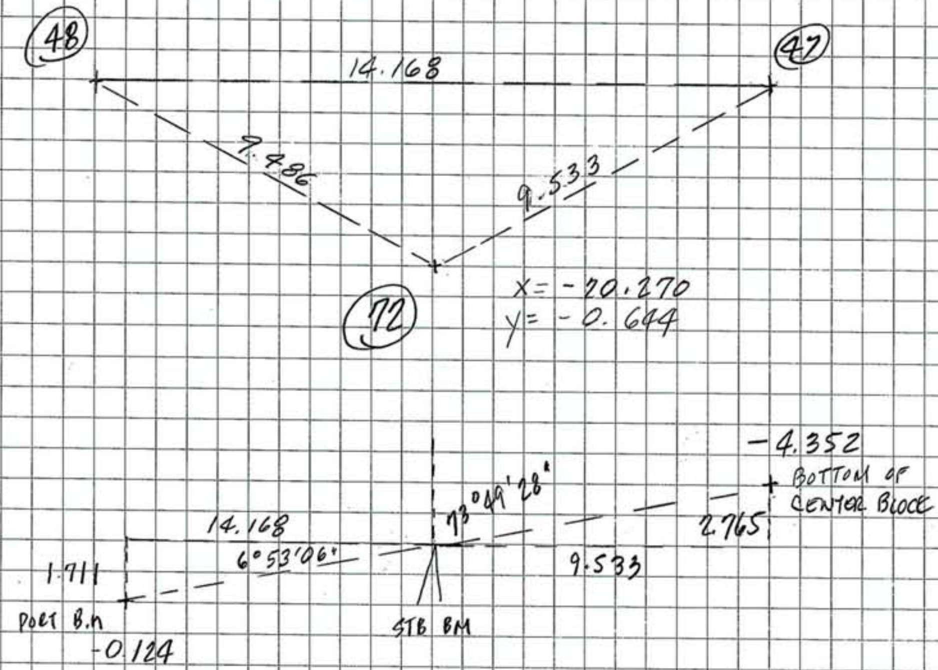
INSTRUMENT ON PORT B.M. - B.S. STARBOARD B.M.

	HORIZ. ∠	AZIMUTH	ZENITH ∠
℄ BOTTOM OF CENTER BLOCK	41°58'22"		
	41°58'06"		
AVG.	41°58'14"	131°58'14	

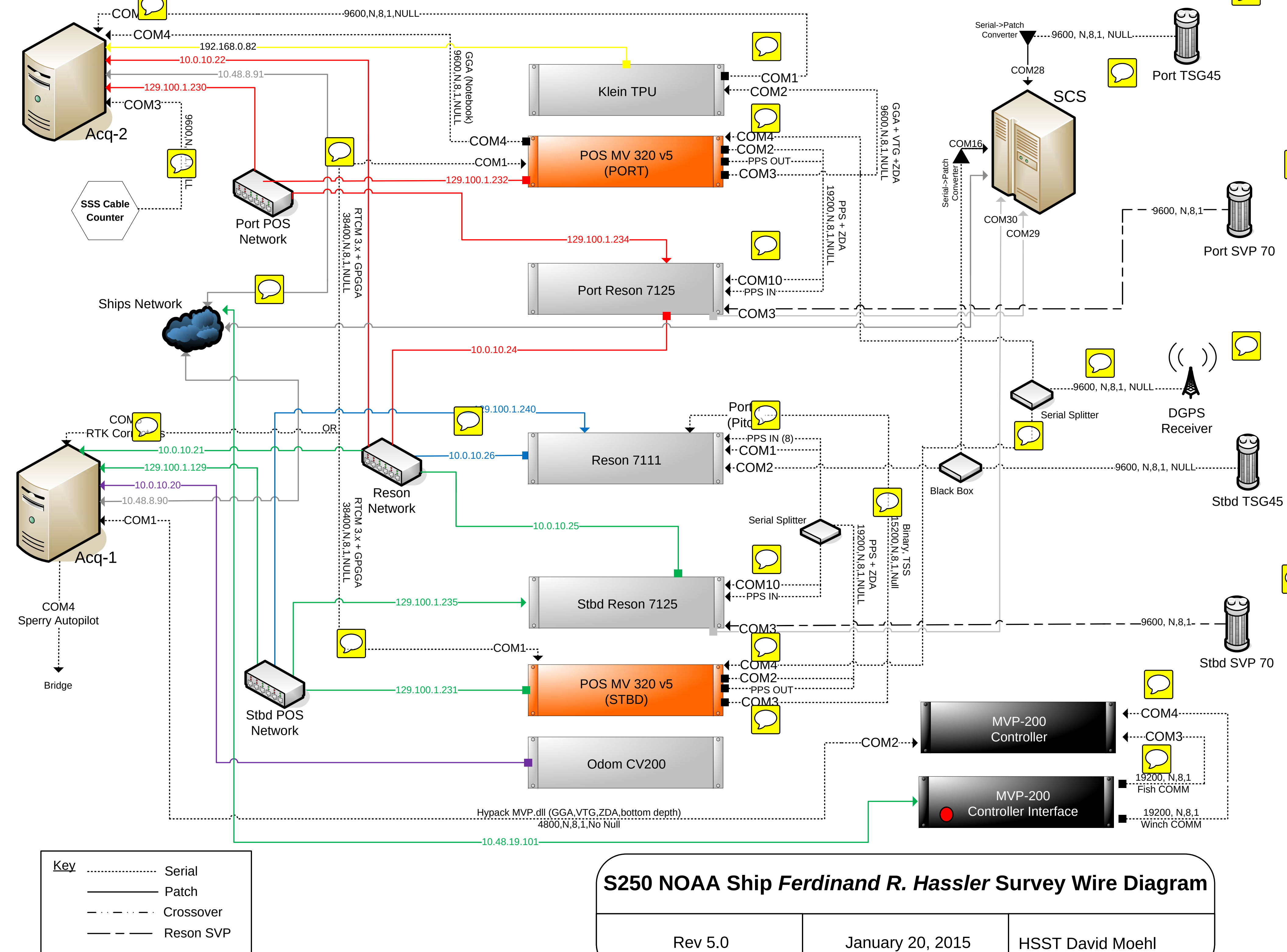
"A" FRAME
CENTER BLOCK (BOTTOM)



RAYMOND C. IMPASTATO PROFESSIONAL LAND SURVEYOR 139 RANCH ROAD SLIDELL, LOUISIANA 70460 PHONE NO: (985) 774-1955 SCALE: 1" = **NONE**	JOB: FERDINAND R. HASSLER M286 SWATH PASCAGOULA, MISSISSIPPI FIELD CREW: R.I. & E.K. CALCULATED BY: R. IMPASTATO DATE: 11-4-09 SHEET NO.: 8



"A" FRAME - CENTER BLOCK

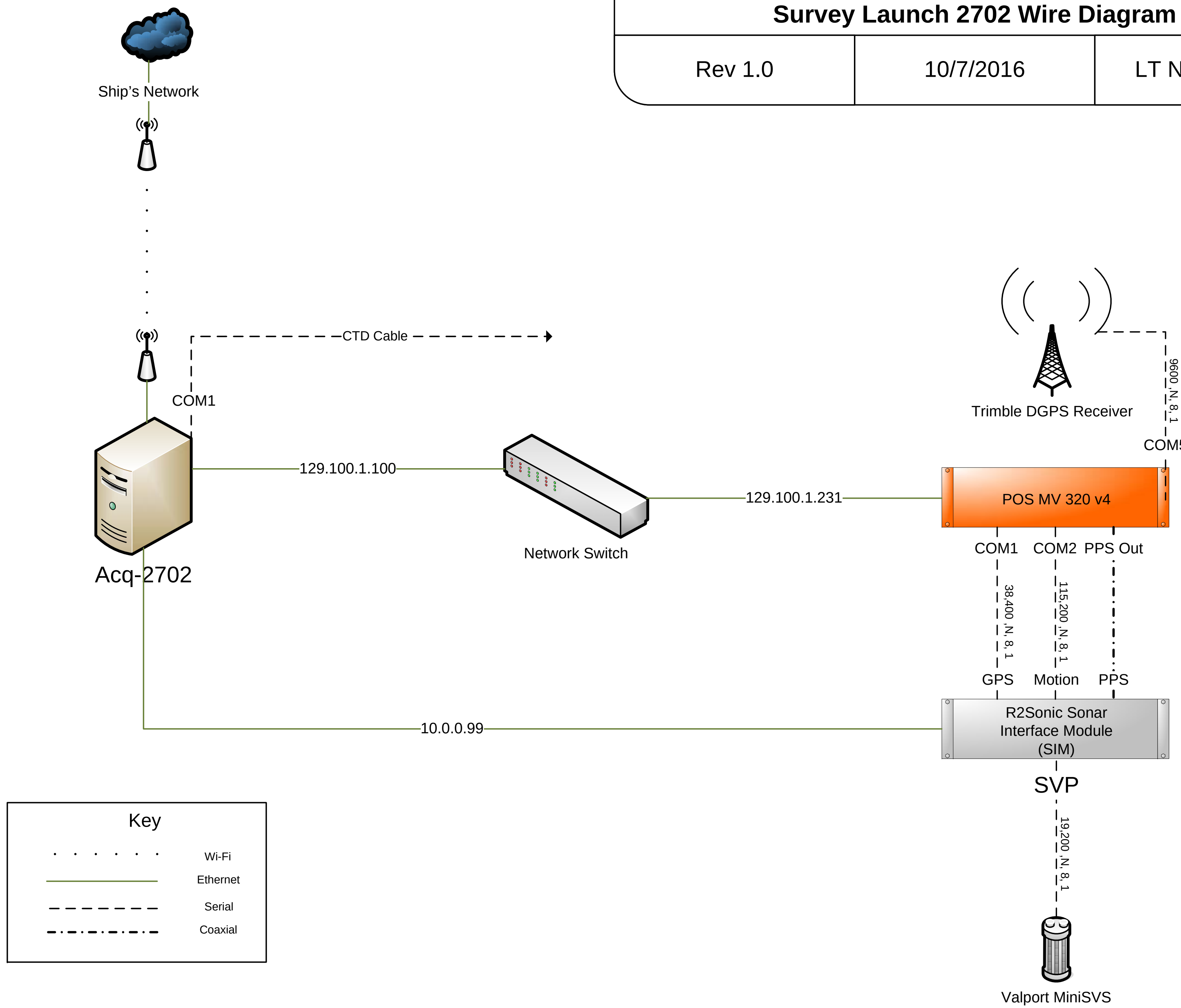


S250 NOAA Ship *Ferdinand R. Hassler* Survey Wire Diagram

Rev 5.0	January 20, 2015	HSST David Moehl

S250 NOAA Ship *Ferdinand R. Hassler*
Survey Launch 2702 Wire Diagram

Rev 1.0	10/7/2016	LT Nick Morgan



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

NOAA SHIP HASSLER
POS ANTENNA and Component Spatial Relationship Survey
Field Report

Kevin Jordan
March, 2011

NOAA Ship Hassler
POS Antenna and Spatial Relationship Survey

PURPOSE

The intention of this survey was to accurately position the relocated POS Antennas and Side Scan Sonar tow point.

PROJECT DETAILS

This survey was conducted on March 29, 2011 on Spring River Island in Pascagoula, MS. NGS was provided data from a previous survey that contained a complete point listing of all components as well as recoverable bench mark stations. The NOAA Ferdinand Hassler was in water causing some instability of the instrument and target reflectors. The tilt compensator had to be bypassed in order to take measurements.

INSTRUMENTATION

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

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

SOFTWARE AND DATA COLLECTION

TDS Survey Pro Ver. 4.7.1

ForeSight DXM Ver. 3.2.2 was used for post processing.

PERSONNEL

Kevin Jordan NOAA/NOS/NGS/Field Operations Branch 757-441-5478

Doug Adams NOAA/NOS/NGS/Field Operations Branch 757-441-5480

NOAA Ship Hassler
POS Antenna and Spatial Relationship Survey

SURVEY PROCEDURES

RECOVERED STATIONS

MID BENCH MARK TOP WHEEL HOUSE


MID_BENCH_MARK_TOP_WHEEL_HOUSE_1


MID_BENCH_MARK_TOP_WHEEL_HOUSE_2

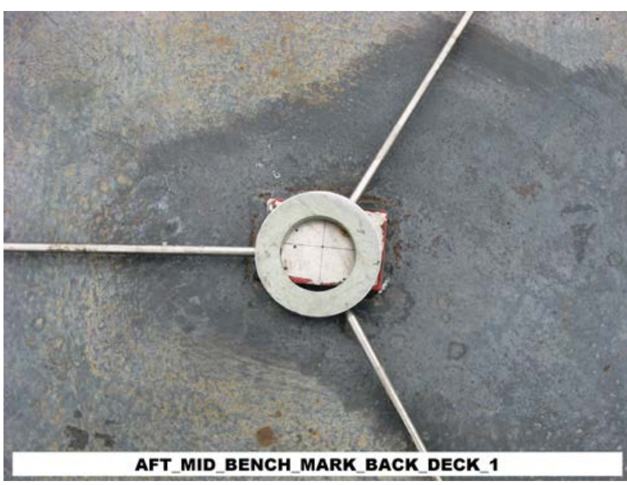
PORT BENCH MARK TOP WHEEL HOUSE


PORT_BENCH_MARK_TOP_WHEEL_HOUSE_1


PORT_BENCH_MARK_TOP_WHEEL_HOUSE_2

STARBOARD BENCH MARK TOP WHEEL HOUSE

AFT MID BENCH MARK BACK DECK



PORT BENCH MARK BACK DECK


PORT_BENCH_MARK_BACK_DECK_1


PORT_BENCH_MARK_BACK_DECK_2

STARBOARD BENCH MARK BACK DECK


STARBOARD_BENCH_MARK_BACK_DECK_1


STARBOARD_BENCH_MARK_BACK_DECK_2

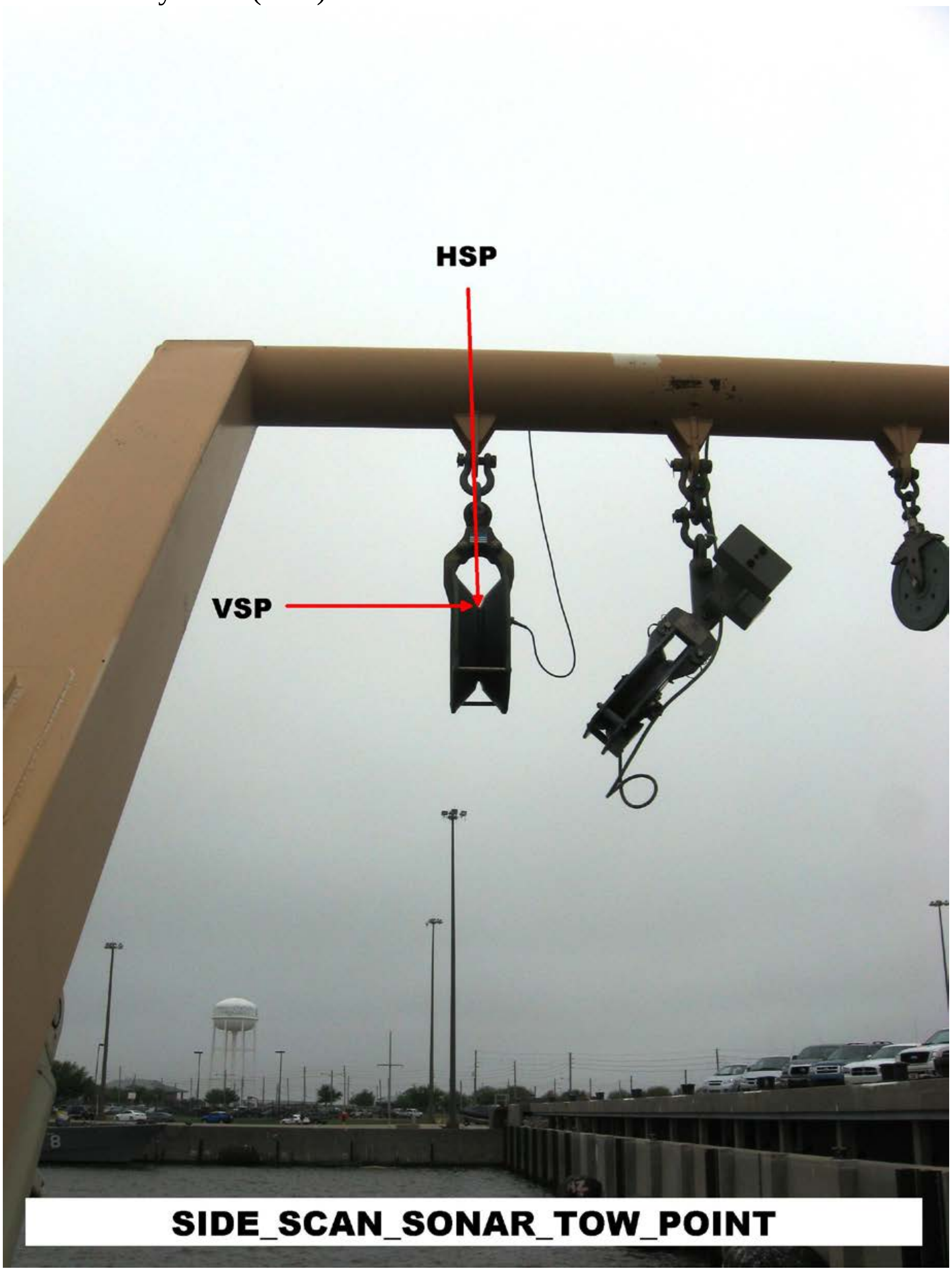
PORT BENCH MARK BRIDGE WING
-NO PHOTOS OF THIS STATION

NEW FEATURES

PORT POS ANTENNA MOUNT

STARBOARD POS ANTENNA MOUNT

SIDE SCAN SONAR TOW POINT
-Horizontal Survey Point (HSP)
-Vertical Survey Point (VSP)



Setup #1
Using the coordinates from the previous survey, the field crew setup the theodolite on the MID BENCH MARK TOP WHEEL HOUSE and initialized on PORT BENCH MARK BRIDGE WING to obtain a starting azimuth. From this setup, we collected the four POS antenna mount locations:

PORT FWD ANTENNA
PORT AFT ANTENNA
STARBOARD FWD ANTENNA
STARBOARD AFT ANTENNA

Positional checks were made to bench mark stations (see attached comparison report):

PORT BENCH MARK TOP WHEEL HOUSE
STARBOARD BENCH MARK TOP WHEEL HOUSE
PORT BENCH MARK BRIDGE WING

A temporary point (TP1) was established on the flying bridge near the stairs in order to collect the location of the SIDE SCAN SONAR TOW POINT.

Setup #2
The field crew setup on TP1 and initialized on the MID BENCH MARK TOP WHEEL HOUSE. From this setup, we collected:

SIDE SCAN SONAR TOW POINT

Positional checks were made to bench mark stations (see attached comparison report):

MID BENCH MARK TOP WHEEL HOUSE
AFT MID BENCH MARK BACK DECK

Setup #3
The field crew setup on AFT MID BENCH MARK BACK DECK and initialized on TP1. Positional checks were made to bench mark stations (see attached comparison report):

PORT BENCH MARK BACK DECK
STARBOARD BENCH MARK BACK DECK

DISCUSSION
All sensor/benchmark coordinates are contained in spreadsheets “NOAA SHIP HASSLER.xls”

The following table includes stations that were observed from more than one setup and for each, an inverse was computed to identify possible setup errors. Each station checked with favorable results.

OBSERVED to PUBLISHED COMPARISON (Units in Meters)			
NAME	**Δ Northing**	**Δ Easting**	**Δ Elevation**
PORT BENCH MARK BRIDGE WING	-0.003	-0.008	0
PORT BENCH MARK TOP WHEEL HOUSE	0.030	-0.015	-0.003
STARBOARD BENCH MARK TOP WHEEL HOUSE	-0.026	0.010	-0.006
MID BENCH MARK TOP WHEEL HOUSE	0.015	0.002	-0.007
AFT MID BENCH MARK BACK DECK	-0.020	-0.030	0.011
PORT BENCH MARK BACK DECK	0.027	-0.002	-0.005
STARBOARD BENCH MARK BACK DECK	-0.015	0.018	-0.011

NEW GPS IMU - NGS 2012

IMU PORT

DESCRIPTION	X	Y	Z
STAR FWD ANT	2.722	9.162	-12.869
STAR AFT ANT	0.719	9.159	-12.895
PORT FWD ANT	2.712	1.05	-12.838
PORT AFT ANT	0.706	1.052	-12.853
STARBOARD BM TOP OF WHEEL HOUSE	10.482	9.395	-10.832
PORT BM TOP OF WHEEL HOUSE	10.482	3.034	-10.807

IMU STBD

DESCRIPTION	X	Y	Z
STAR FWD ANT	2.698	-3.084	-12.87
STAR AFT ANT	0.695	-3.087	-12.896
PORT FWD ANT	2.688	-11.196	-12.839
PORT AFT ANT	0.682	-11.194	-12.854
STARBOARD BM TOP OF WHEEL HOUSE	10.458	-2.851	-10.833
PORT BM TOP OF WHEEL HOUSE	10.458	-9.212	-10.808

PURPOSE

During the 2012 field season it was discovered that previously determined offsets from the original ship survey (Impastato, 2009) were in need of refinements. Results from 2012 post-processed POSPac derived offset solutions and ellipsoidally referenced leadline (ERLL) measurements showed a difference of approximately 20 centimeters in the vertical direction. This error was floating somewhere between the navigation GPS antennas, IMU and transducers. An attempt to track down this error was performed by *Ferdinand R. Hassler* personnel during the drydock period (April 2013) at Colonna's Shipyard in Norfolk, VA.

METHODS

A calibrated optical level was utilized to obtain a closed loop of elevations on important points and sensors around the ship. These elevations are with respect to gravity, in order to transform them to the ship's reference frame (SRF) an additional loop was obtained containing known benchmark elevations. From these benchmark elevations, values for pitch and roll were computed.

The primary sensor loop contained elevations from the starboard forward (primary) POS antenna on the flying bridge to a temporary benchmark (TBM) located on the drydock floor. From the TBM the loop proceeded to close by way of the port forward POS antenna and a final closing shot between the two antennas. This resulted in a closed loop with less than 5 millimeters of calculated misclosure.

The TBM on the drydock floor was utilized for spurs to survey sensors. Each individual sensor was treated separately and closed with a misclosure computed in the calculation spreadsheet. Both IMU's was measured using a level and tape measure from known point via the cable route (7125's and cables were removed for shipyard period). The 7125 elevations were computed from the averaged elevation readings on the inboard and outboard base of frame, accounting for the manufactured 4.5 degree tilt.

A total station was utilized to obtain elevations on all eight draft marks permanently fixed on the ship's hull. A reflectorless (laser) measurement device measured the vertical distance relative to a level gravimetric plane of the instrument.

To obtain results a couple of points were assumed:

1) The ship reference frame is accurately documented and defined from the Impastato ship survey. From the established benchmarks we are able to recreate the ship reference frame and apply pitch/roll calculations correctly.

2) Coordinates provided from Impastato are correct until proven otherwise. We use distances from the master reference block (MRB) for applying the pitch/roll offsets but strongly disagree with many of his z-coordinates. Also, along with #1; benchmarks utilized were crucial in recreating the ships reference frame.

3) Distances from the MRB for applying pitch/roll offsets is close enough to the center of gravity for the vessel to accurately apply pitch and roll.

4) The *Hassler* is located in a floating drydock which is subject to outside influences (e.g. tide, current, wind). However, the influences will affect both drydock and ship at the same rate and therefore be negligible.

RESULTS

Ship Reference Frame:

One of the primary issues with surveying a ship is orientating results obtained via outside reference frames (e.g gravity) into the SRF. During the Impastato ship survey, the surveyor defined the ship's master reference frame by measuring the pitch and roll of each pontoon and averaging these values. From this point he established various benchmarks located around the vessel; including the MRB, IMU plates, transducers and antennas. It is from this original survey benchmarks that enable us to transform coordinates relative to the SRF.

A level loop was run from a benchmark established by FH personnel on the bow of the *Hassler* to two benchmarks established by Impastato on the aft corners. From these three benchmarks we figured the difference of design slope to actual slope for both pitch and roll. The correction was corrected with the distance from the MRB, which is near but not located at the center of gravity (motion) for the vessel. This appears to be the same strategy utilized by Impastato during the original survey.

Ship Sensors:

Through careful analysis of the main level loop and the spurs to each individual sensor located on the pontoons, the following offsets were obtained.

Sensor	**Corrected height from Antenna Base**		**Corrected height from IMU**	
Port IMU (base of plate)	-12.990	Port	--	--
Starboard IMU (base of plate)	-12.990	Starboard	--	--
7125 Port (middle Rx)	-14.203	Port	-1.213	Port
7125 Starboard (middle Rx)	-14.212	Starboard	-1.222	Starboard
7111 (middle Rx)	-14.149	Starboard	-1.159	Starboard
Port VBES	-14.236	Starboard	-1.245	Starboard
Starboard VBES	-14.237	Starboard	-1.247	Starboard

Table 1: 2013 Sensor Offset Results

Comparisons were made from the 2013 sensor offset results with offsets used previously during the 2012 season. Two sets of z-offsets were used during the 2012 season; those obtained through Impastato ship survey coordinates and those obtained through post-processed POSPac results (supported through ERLL results). The results of the delta Z values (2013 minus 2012) are shown below in Table 2.

Sensor	Delta Z (m) (Impastato)	Delta Z (m) (Revised)	Notes and Analysis
Stbd IMU -> Stbd APC	0.225	-0.002	Revised measurements from POSPac and ERLL; 2013 survey values strongly agree with revised results.
Port IMU -> Port APC	0.212	-0.019	Revised measurements from POSPac; 2013 survey values strongly agree with revised results.
Stbd IMU -> 7111 Rx	-0.171	n/a	No revisions were made between the Stbd IMU and 7111 Rx.
Stbd APC -> 7111 Rx	0.176	n/a	No revisions were made between the Stbd APC and 7111 Rx.
Stbd IMU -> 7125S Rx	-0.103	-0.011	Revised measurements were never used; 2013 survey values show disagreement between IMU and sensor.
Stbd APC -> 7125S Rx	0.244	-0.105	Revised measurements from POSPac and ERLL; 2013 survey values show same disagreement between IMU and sensor.
Port IMU -> 7125P Rx	-0.105	0.011	Revised measurements were never used; 2013 survey values show disagreement between IMU and sensor.
Port APC -> 7125P Rx	0.229	-0.123	Revised measurements from POSPac; 2013 survey values show same disagreement between IMU and sensor.

Table 2: Delta Values between 2013 and 2012

Draft Marks:

Field elevation measurements were corrected using the same pitch and roll constants as stated earlier. For this calculation the X/Y locations of the draft marks were obtained from Impastato ship survey.

Forward Port Outboard	Forward Port Inboard	Forward Stbd Inboard	Forward Stbd Outboard
2.57	2.58	2.52	2.52
2.77	2.78	2.71	2.71
2.97	2.98	2.92	2.91
3.16	3.18	3.12	3.11
3.37	3.38	3.32	3.30
3.57	3.58	3.52	3.51
3.77	3.78	3.71	3.71
3.97	3.98	3.92	3.91
4.17	4.18	4.12	4.11
4.37	4.38	4.32	4.31
4.57	4.58	4.52	4.51

After Port Outboard	After Port Inboard	After Stbd Inboard	After Stbd Outboard
2.58	2.58	2.61	2.59
2.78	2.77	2.81	2.80
3.99	2.97	3.01	2.99
3.18	3.17	3.21	3.20
3.38	3.37	3.41	3.40
3.58	3.57	3.61	3.60
3.79	3.78	3.81	3.80
3.98	3.98	4.01	4.00
4.18	4.18	4.21	4.20
4.38	4.38	4.41	4.40
4.58	4.58	4.61	4.60

Table 3: Draft Mark Elevations relative from MRB (z is positive down)

Ship Traverse:

While in our possession the total station instrument was utilized for a ship traverse of existing benchmarks and POS antennas; as well as recreating the original SRF from the Impastato survey. Methods for this traverse were not as complete as was desired due to inadequate equipment and training of personnel. However, the calculations serve as additional checks against prior surveys and because an X/Y position was established on the TBM, help tie all previously discussed methods into a complete survey. More calculations are required on these acquired data once defined goals are obtained.

<u>CONCLUSIONS</u>

Vertical offsets from the level loop agree closely with offsets derived from post-processed POSPac solutions and ERLL calculations resulting in more confidence of both these methods. Hours were spent overlooking Impastato's original survey notes for any indication of possible errors or blunders but none were found. From these results it is safe to say that there were errors and possibly an overall miscommunication of exact reference points for measurement. *Ferdinand R. Hassler*'s 2013 offsets will be defined from an in-depth analysis of these results and subsequent ERLL and reference surfaces to be acquired during Hydrographic Systems Readiness Review 2013.

Draft marks appear to near locations defined by Impastato as well as being generally level with respect to the ship reference frame; however, it appears that there is a disagreement with the forward starboard draft marks.

Offsets: POS MV

Measurement	Port IMU to Fwd Port Ant		Stbd IMU to Fwd Stbd Ant		Stbd IMU to Heave		Stbd IMU to Heave	
Coord. Sys.	Caris	POSMV	Caris	POSMV	Caris	POSMV	Caris	POSMV
x	1.002	2.713	-3.104	2.700	NA	NA	NA	NA
y	2.713	1.002	2.700	-3.104	NA	NA	NA	NA
z	-12.920	-12.920	-12.920	-12.920	NA	NA	NA	NA

Stbd Ant Seperation	
(from calc)	
Scaler Distance	2.000

Port Ant Seperation	
(from calc)	
Scaler Distance	2.006

Stbd Ant Seperation	
(from GAMS Cal)	
Scaler Distance	

Port Ant Seperation	
(from GAMS Cal)	
Scaler Distance	

POSMV offsets are derived from measurements by FH personnel made April 2012 after installation of new lever arm mounts and April 2013 during drydock.

Calculations

Port IMU to Fwd Port Ant			Stbd IMU to Fwd Stbd Ant		
Adapter Plate to top of IMU	x	0.000	**Adapter Plate to top of IMU**	x	0.000
	y	0.000		y	0.000
	z	0.1236		z	0.1236
(from POSMV V5 User Guide)		(in POSMV)	(from POSMV V5 User Guide)		(in POSMV)
Adapter Plate	x	0.000	**Adapter Plate**	x	0.000
	y	0.000		y	0.000
	z	0.012		z	0.012
from physical measurement		(in POSMV)	from physical measurement		(in POSMV)
Center of Port IMU Plate to Fwd Port Antenna Base	x	2.713	**Center of Stbd IMU Plate to Fwd Stbd Antenna Base**	x	2.700
	y	1.002		y	-3.104
	z	-12.990		z	-12.990
(x/y from 2012 POSPac, z from FH 2013 drydock measurements)		(in POSMV)	(x/y from 2012 POSPac, z from FH 2013 drydock measurements)		(in POSMV)
Antenna base to phase center	x	0.000	**Antenna base to phase center**	x	0.000
	y	0.000		y	0.000
	z	-0.066		z	-0.066
(from Trimble diagram)		(in POSMV)	(from Trimble diagram)		(in POSMV)

Top of Port IMU to Fwd Port Ant			Top of Stbd IMU to Fwd Stbd Ant		
Top of Port IMU to aft port ant phase center	x	2.713	Top of Stbd IMU to fwd port ant phase center	x	2.700
	y	1.002		y	-3.104
	z	-12.920		z	-12.920
		(in POSMV)			(in POSMV)

PosPac Derived Offsets

Port IMU to Fwd Port Ant		Stbd IMU to Fwd Stbd Ant	
(from 2013 calculations)		(from 2013 calculations)	
x	2.713	x	2.700
y	1.002	y	-3.104
z	-12.920	z	-12.920

Port	y	6.123
STBD	y	-6.123

x and z zero

Port IMU to Fwd Port Ant			Stbd IMU to Fwd Stbd Ant		
(from PosPac calibration)			(from PosPac calibration)		
	average			average	
x			x		
y			y		
z			z		

*calculated averages between multiple days

Ref to Center of Rotation
(Top of Stbd IMU to Center of Rotation)

POSMV
-3.705
-6.033
-2.270

(from waterline)
Added to Pos on DN285 2012

Offsets: Port 7125

Measurement Coord. Sys.	Port IMU to Port 7125 (MRU to Trans)		Fwd Port Ant to Port 7125 (Nav to Trans)		Projector to Receiver		Hysweep Offsets		
		Caris		Caris		Reson			Hypack
x		-1.244		-2.246		0.000	Port IMU to Port 7125	Stbd	-1.244
y		0.362		-2.351		-0.441		Fwd	0.362
z		1.349		14.269		0.047		Vertical	3.780
	TILTED 4.5 degrees up to port *Top of IMU is RP (Reference Pt)				(from Reson diagram, entered in Reson Hardware configuration)		TILTED 4.5 degrees up to port (Hypack vertical is positive down from waterline.)		

Offsets are derived from Impastato Centerline Survey (2010) and measurements by FH personnel made April 2012 after installation of new lever arm mounts and April 2013 during drydock.

Calculations

Port IMU to Port 7125

Top of IMU to center of IMU Plate	x	0.000
	y	0.000
	z	0.1356
(from POSMV V5 User Guide)		(in CARIS)
Port IMU Plate to Port 7125	x	-1.244
	y	0.362
	z	1.213
(x/y from Impastato, Z from 2013 drydock)*		(in CARIS)

Port IMU to Port 7125

x	-1.244
y	0.362
z	1.349
	(in CARIS)

Fwd Port Ant to Port 7125

Antenna Phase Center to IMU Ref Pt	x	-1.002
	y	-2.713
	z	12.920
(from POS MV calculation tab)		(in CARIS)
Port IMU RP to Port 7125	x	-1.244
	y	0.362
	z	1.349
(x/y from Impastato, Z from 2013 drydock)		(in CARIS)

Fwd Port Ant to Port 7125 RP

x	-2.246
y	-2.351
z	14.269
	(in CARIS)

Reson Projector to Receiver

Tx RP	x	0.000
	y	0.000
	z	0.000
(from Reson diagram)		(in Reson)
Rx RP	x	0.000
	y	0.441
	z	-0.047
(from Reson diagram and 2013 drydock)		(in Reson)

Reson Projector to Receiver

x	0.000
y	-0.441
z	0.047
	(in Reson)

Waterline to Stbd 7125 RP

Port IMU RP to Port 7125 RP	x	-1.244
	y	0.362
	z	1.349
(from calculations)		(in CARIS)
Top Port IMU to Waterline	x	0.000
	y	0.000
	z	2.431
(from waterline spreadsheet)		(in Hypack)

Waterline to Stbd 7125 RP

x	-1.244
y	0.362
z	3.780
	(in Hypack)

CALCULATION NOTES

Z calc includes 0.015 m from base to RP

Impastato X/Y measurement locations unknown

0.102	from Reson diagram - Rx width
0.25	from 2013 drydock - Gap between Rx and Tx
0.28	from Reson diagram - Tx length
0.003656	4.5° tilt calculated from Tx diameter
0.046456	4.5° tilt calculated from Tx diameter

Offsets: Starboard 7125

Measurement Coord. Sys.	Stbd IMU to Stbd 7125 (MRU to Trans) Caris	Fwd Stbd Ant to Stbd 7125 (Nav to Trans) Caris	Reson Projector to Receiver Reson	Hysweep Offsets		Hypack
x	1.424	4.528	0.000	Stbd IMU to Stbd 7125	Stbd	1.424
y	0.380	-2.320	-0.437		Fwd	0.380
z	1.358	14.278	0.047		Vertical	3.789
	TILTED 4.5 degrees up to stbd *Top of IMU is RP (Reference Pt)		(from Reson diagram, entered in Reson Hardware configuration)	TILTED 4.5 degrees up to stbd (Hypack vertical is positive down from waterline.)		

Offsets are derived from Impastato Centerline Survey (2010) and measurements by FH personnel made April 2012 after installation of new lever arm mounts and April 2013 during drydock.

Calculations

Stbd IMU to Stbd 7125

Top of IMU to Center of IMU Plate	x	0.000
	y	0.000
	z	0.1356
(from POSMV V5 User Guide)		(in CARIS)
IMU Plate to Stbd 7125	x	1.424
	y	0.380
	z	1.222
(x/y from Impastato, Z from 2013 drydock)*		(in CARIS)
Stbd IMU to Stbd 7125 RP	x	1.424
	y	0.380
	z	1.358
		(in CARIS)

Fwd Stbd Ant to Stbd 7125

Antenna Phase Center to IMU Ref Pt	x	3.104
	y	-2.700
	z	12.920
(from POS MV calculation tab)		(in CARIS)
Stbd IMU RP to Stbd 7125	x	1.424
	y	0.380
	z	1.358
(x/y from Impastato, Z from 2013 drydock)		(in CARIS)
Fwd Stbd Ant to Stbd 7125 RP	x	4.528
	y	-2.320
	z	14.278
		(in CARIS)

Reson Projector to Receiver

Tx RP	x	0.000
	y	0.000
	z	0.000
(from Reson diagram)		(in Reson)
Rx RP	x	0.000
	y	0.437
	z	-0.047
(from Reson diagram and 2013 drydock)*		(in Reson)
Reson Projector to Receiver	x	0.000
	y	-0.437
	z	0.047
		(in Reson)

Waterline to Stbd 7125 RP

Stbd IMU RP to Stbd 7125 RP	x	1.424
	y	0.380
	z	1.358
(from calculations)		(in CARIS)
Top Stbd IMU to Waterline	x	0.000
	y	0.000
	z	2.431
(from waterline spreadsheet)		(in Hypack)
Waterline to Stbd 7125 RP	x	1.424
	y	0.380
	z	3.789
		(in Hypack)

<u>*CALCULATION NOTES*</u>

Z calc includes 0.015 m from base to RP

Impastato X/Y measurement locations unknown

0.102	from Reson diagram - Rx width
0.246	from 2013 drydock - Gap between Rx and Tx
0.28	from Reson diagram - Tx length
0.003656	4.5° tilt calculated from Tx diameter
0.046456	4.5° tilt calculated from Tx diameter

Offsets: Starboard 7111

Measurement	IMU to 7111 (MRU to Trans)		Fwd Stbd Ant to 7111 (Nav to Trans)		Reson Projector to Receiver		Hysweep Offsets		
Coord. Sys.		Caris		Caris		Reson			Hypack
x		1.203		4.307		0.000	Stbd IMU to 7111 RP	Stbd	1.203
y		11.608		8.908		-0.499		Fwd	11.608
z		0.977		13.897		-0.269		Vertical	3.408

*Top of IMU is RP (Reference Pt)

(from Reson diagram, entered in Reson Hardware configuration)

(Hypack vertical is positive down from waterline.)

Offsets are derived from Impastato Centerline Survey (2010) and measurements by FH personnel made April 2012 after installation of new lever arm mounts and April 2013 during drydock.

Calculations

Stbd IMU to 7111			Fwd Stbd Ant to 7111 RP			Reson Projector to Receiver			Waterline to 7111 RP		
Top of IMU to Center of IMU Plate	x	0.000	Antenna Phase Center to IMU RP	x	3.104	Tx RP	x	0.000	Top Stbd IMU to 7111 RP	x	1.203
	y	0.000		y	-2.700		y	0.000		y	11.608
	z	0.1356		z	12.920		z	0.000		z	0.977
(from POSMV V5 User Guide)		(in CARIS)	(from POS MV calculation tab)		(in CARIS)	(from Reson diagram)		(in Reson)	(from calculations)		(in CARIS)
IMU Plate to 7111 Rx Face	x	1.203	IMU RP to 7111 Acoustic RP	x	1.203	Rx RP	x	0.000	Top Stbd IMU to Waterline	x	0.000
	y	12.107		y	11.608		y	0.499		y	0.000
	z	1.159		z	0.977		z	0.269		z	2.431
(x/y from Impastato, Reson diagram and 2013 drydock, z from 2013 drydock)*		(in CARIS)	(x/y from Impastato and Reson diagram, z from 2013 drydock)		(in CARIS)	(from Reson diagram and 2013 drydock)*		(in Reson)	(from waterline spreadsheet)		(in Hypack)
7111 Rx Face to 7111 Acoustic RP	x	0.000									
	y	-0.499									
	z	-0.318									
(from Reson diagram)		(in CARIS)									

Top of Stbd IMU to 7111 RP		Fwd Stbd Ant RP to 7111 RP		Reson Projector to Receiver		Waterline to 7111 RP	
x	1.203	x	4.307	x	0.000	x	1.203
y	11.608	y	8.908	y	-0.499	y	11.608
z	0.977	z	13.897	z	-0.269	z	3.408
	(in CARIS)		(in CARIS)		(in Reson)		(in Hypack)

CALCULATION NOTES

1.203	from Impastato - CL IMU to CL Plate
11.77	from Impastato - CL IMU to CL Plate
0.05341	from Reson diagram - CL Plate to Mounting Bolt
0.434	from Reson diagram - Mounting Bolt to aft Tx
0.65	from Reson diagram - Tx overall length
0.125	from 2013 drydock - Gap between Tx and Rx
0.0982	from Reson diagram - Rx thickness
0.098	from Reson diagram - Tx diameter

Sanity Check

Physical measurement =	11.150	+/- 20 cm
calc measurement =	11.228	
diff =	-0.078	

Offsets: Dual 7125 (HSX only)

Measurement Coord. Sys.	Stbd IMU to Port 7125 (MRU to Trans) - Swath 1	Stbd IMU to Stbd 7125 (MRU to Trans) - Swath 2	Fwd Stbd Ant to Port 7125 (Nav to Trans)	Fwd Stbd Ant to Stbd 7125 (Nav to Trans)	Port 7125 Hysweep Offsets			Stbd 7125 Hysweep Offsets		
	Caris	Caris	Caris	Caris			Hypack			Hypack
x	-13.490	1.424	-10.386	4.528	Stbd IMU to Port 7125	Stbd	-13.490	Stbd IMU to Stbd 7125	Stbd	1.424
y	0.338	0.380	-2.362	-2.320		Fwd	0.338		Fwd	0.380
z	1.314	1.358	14.234	14.278		Vertical	3.745		Vertical	3.789

*Top of Stbd IMU is RP (Reference Pt)
Tilted up 4.5 degrees up on both sides

TILTED 4.5 degrees up to port
(Hypack vertical is positive down from waterline.)

TILTED 4.5 degrees up to stbd

Offsets are derived from Impastato Centerline Survey (2010) and measurements by FH personnel made April 2012 after installation of new lever arm mounts and April 2013 during drydock.

Calculations

Stbd IMU to Port 7125

top of IMU toCenter of Stbd IMU Plate	x	0.000
	y	0.000
	z	0.1356
(from POSMV V5 User Guide)		(in CARIS)
Stbd IMU Plate to Port IMU Plate	x	-12.246
	y	-0.024
	z	-0.035
(x/y from Impastato, Z from 2013 Drydock)		(in CARIS)
Port IMU Plate to Port 7125	x	-1.244
	y	0.362
	z	1.213
(x/y from Impastato, Z from 2013 Drydock)		(in CARIS)

Stbd IMU to Stbd 7125

top of IMU to Center of IMU Plate	x	0.000
	y	0.000
	z	0.1356
(from POSMV V5 User Guide)		(in CARIS)
IMU Plate to Stbd 7125	x	1.424
	y	0.380
	z	1.222
(x/y from Impastato, Z from 2013 Drydock)		(in CARIS)

Fwd Stbd Ant to Port 7125

Fwd Stbd Ant to Stbd IMU RP	x	3.104
	y	-2.700
	z	12.920
(from POS MV calculation tab)		(in CARIS)
Stbd IMU RP to Port 7125	x	-13.490
	y	0.338
	z	1.314
(x/y from Impastato, Z from 2013 drydock)		(in CARIS)

Fwd Stbd Ant to Stbd 7125

Fwd Stbd Ant to Stbd IMU RP	x	3.104
	y	-2.700
	z	12.920
(from POS MV calculation tab)		(in CARIS)
Stbd IMU RP to Stbd 7125	x	1.424
	y	0.380
	z	1.358
(x/y from Impastato, Z from 2013 drydock)		(in CARIS)

Waterline to Stbd 7125 RP

Top Stbd IMU to Port 7125 RP	x	-13.490
	y	0.338
	z	1.314
(from calculcations)		(in CARIS)
Top Stbd IMU to Waterline	x	0.000
	y	0.000
	z	2.431
(from waterline spreadsheet)		(in Hypack)

Waterline to Stbd 7125 RP

Top Stbd IMU to Stbd 7125 RP	x	1.424
	y	0.380
	z	1.358
(from calculcations)		(in CARIS)
Top Stbd IMU to Waterline	x	0.000
	y	0.000
	z	2.431
(from waterline spreadsheet)		(in Hypack)

	Stbd IMU to Port 7125 RP	Stbd IMU to Stbd 7125 RP	Fwd Stbd Ant to Port 7125 RP	Fwd Stbd Ant to Stbd 7125 RP	Waterline to Stbd 7125 RP	Waterline to Stbd 7125 RP
x	-13.490	1.424	-10.386	4.528	-13.490	1.424
y	0.338	0.380	-2.362	-2.320	0.338	0.380
z	1.314	1.358	14.234	14.278	3.745	3.789
	(in CARIS)	(in CARIS)	(in CARIS)	(in CARIS)	(in Hypack)	(in Hypack)

Note: For dual acquisition 7125, the HSX file contains data from both 7125s but only POSMV data from the stbd POSMV. The port 7125 is swath 1 (beams 1-512) and the stbd 7125 is swath 2 (beams 513 to 1024).

Offsets: ODOM Single Beam

Measurement Coord. Sys.	Stbd IMU to Stbd SB		Stbd IMU to Port SB		Fwd Stbd Ant to Stbd SB		Fwd Stbd Ant to Port SB	
		Caris		Caris		Caris		Caris
x		-0.455		-12.701		2.649		-9.597
y		4.620		4.620		1.920		1.920
z		1.383		1.381		14.303		14.301
	(x/y from Impastato, Z from 2013 drydock)	(in CARIS)	(x/y from Impastato, Z from 2013 drydock)	(in CARIS)				

Port 7125 Hysweep Offsets		Hypack
Stbd IMU to Stbd SB	Stbd	-0.455
	Fwd	4.620
	Vertical	3.835

TILTED 4.5 degrees up to port

(Hypack vertical is positive down from waterline.)

Stbd 7125 Hysweep Offsets		Hypack
Stbd IMU to Port SB	Stbd	-12.701
	Fwd	4.620
	Vertical	3.861

TILTED 4.5 degrees up to stbd

Calculations

Stbd IMU to Stbd SB			Stbd IMU to Port SB			Fwd Stbd Ant to Stbd SB			Fwd Stbd Ant to Port SB		
top of IMU to Center of IMU Plate	x	0.000	top of IMU to Center of IMU Plate	x	0.000	Fwd Stbd Ant to Stbd IMU RP	x	3.104	Fwd Stbd Ant to Stbd IMU RP	x	3.104
	y	0.000		y	0.000		y	-2.700		y	-2.700
	z	0.1356		z	0.1356		z	12.920		z	12.920
(from POSMV V5 User Guide)		(in CARIS)	(from POSMV V5 User Guide)		(in CARIS)	(from POS MV calculation tab)		(in CARIS)	(from POS MV calculation tab)		(in CARIS)
Stbd IMU Plate to Stbd SB	x	-0.455	Stbd IMU Plate to Port SB	x	-12.701	Stbd IMU to Stbd SB	x	-0.455	Stbd IMU to Port SB	x	-12.701
	y	4.620		y	4.620		y	4.620		y	4.620
	z	1.247		z	1.245		z	1.383		z	1.381
(x/y from Impastato, Z from 2013 drydock)*		(in CARIS)	(x/y from Impastato, Z from 2013 drydock)*		(in CARIS)	(x/y from Impastato, Z from 2013 drydock)		(in CARIS)	(x/y from Impastato, Z from 2013 drydock)		(in CARIS)
Stbd IMU to Stbd SB			**Stbd IMU to Stbd SB**			**Fwd Stbd Ant to Port 7125 RP**			**Fwd Stbd Ant to Stbd 7125 RP**		
	x	-0.455		x	-12.701		x	2.649		x	-9.597
	y	4.620		y	4.620		y	1.920		y	1.920
	z	1.383		z	1.381		z	14.303		z	14.301
		(in CARIS)			(in CARIS)			(in CARIS)			(in CARIS)

Waterline to Stbd SB RP			Waterline to Port SB RP		
Stbd IMU RP to Stbd SB RP	x	-0.455	Stbd IMU RP to Port SB RP	x	-12.701
	y	4.620		y	4.620
	z	1.383		z	1.381
(from calculations)		(in CARIS)	(from calculations)		(in CARIS)
Top Stbd IMU to Waterline	x	0.000	Top Stbd IMU to Waterline	x	0.000
	y	0.000		y	0.000
	z	2.431		z	2.431
(from waterline spreadsheet)		(in Hypack)	(from waterline spreadsheet)		(in Hypack)
Waterline to Stbd 7125 RP			**Waterline to Stbd 7125 RP**		
	x	-0.455		x	-12.701
	y	4.620		y	4.620
	z	3.835		z	3.861
		(in Hypack)			(in Hypack)

Offsets: Klein 5000

Measurement	Port IMU to TowPoint	
Coord. Sys.		Caris
x		7.161
y		-26.032
z		-9.347
		(in CARIS)

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

HASSLER LAUNCH 2702
Component Spatial Relationship Survey
Field Report

Kevin Jordan
June 16, 2015

PURPOSE

The intention of this survey was to accurately position the POS/MV IMU, GPS Antennas, Sonar Equipment, bench marks, and reference marks located on the 2702 Launch.

PROJECT DETAILS

This survey was conducted on June 16, 2015 at the Kittery Point Yacht Yard in Eliot, ME. The launch was placed jack stands to stabilize the launch during the survey.

INSTRUMENTATION

The TOPCON GPT 3000 Series Theodolite was used to position all points on the launch.

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

SOFTWARE AND DATA COLLECTION

TDS Survey Pro Ver. 4.7.1

ForeSight DXM Ver. 3.2.2 was used for post processing.

PERSONNEL

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

Temporary Control

A network of temporary control was established at KPYY consisting or two marks set on the ground. One mark was 10 meters behind the boat and the other was 13 meters off the starboard side.

OBSERVED POINTS

AFT BENCHMARK

PORT BENCHMARK

STARBOARD BENCHMARK

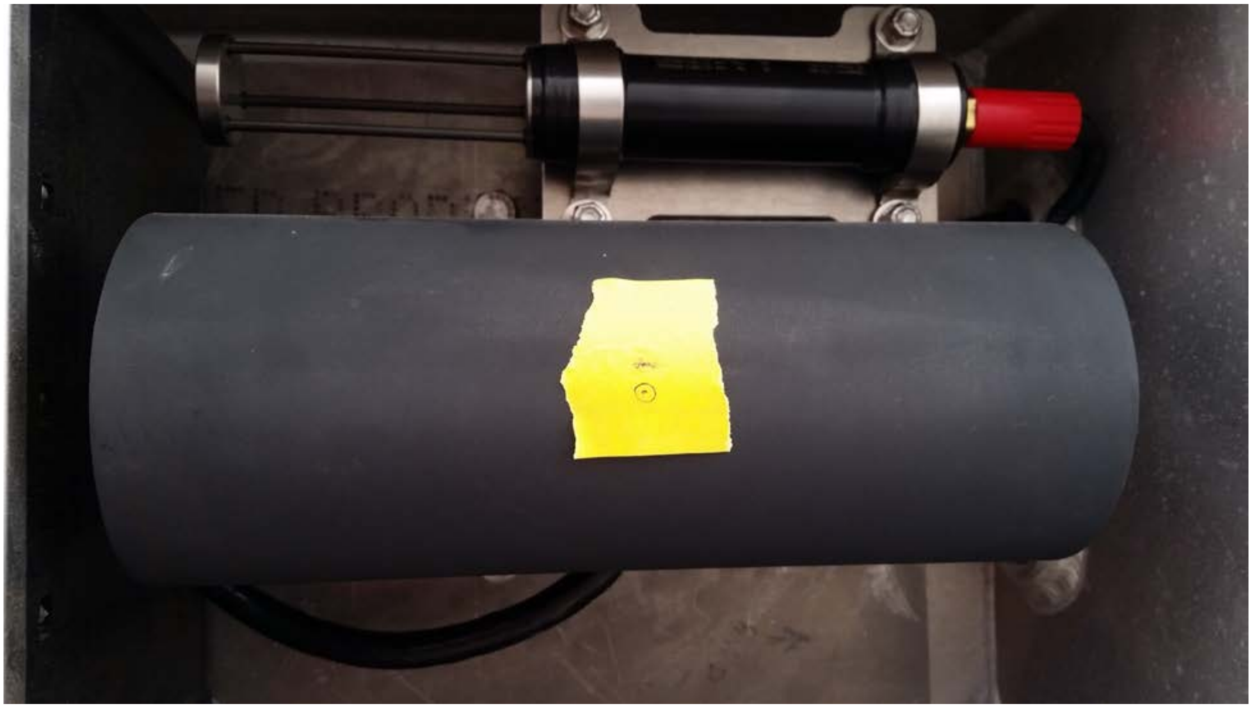
FWD BENCHMARK

IMU

NOTE: The four corners of the IMU were observed, but presented a challenge due to low overhead above the IMU and the rounded corners of the IMU. The best attempt was made using a plumb bob and prism.

Coordinates for these points are listed in the coordinate spreadsheet.

TRANSMITTER



RECEIVER

STARBOARD GPS ARP (BOTTOM OF ANTENNA)

PORT GPS ARP (BOTTOM OF ANTENNA)

R I (REFERENCE MARK ONE)

R II (REFERENCE MARK TWO)

R III (REFERNCE MARK THREE) (NEAR IMU)

R IV (REFERENCE MARK FOUR)

PLUMB MARK OVER R IV

POST PROCESSING

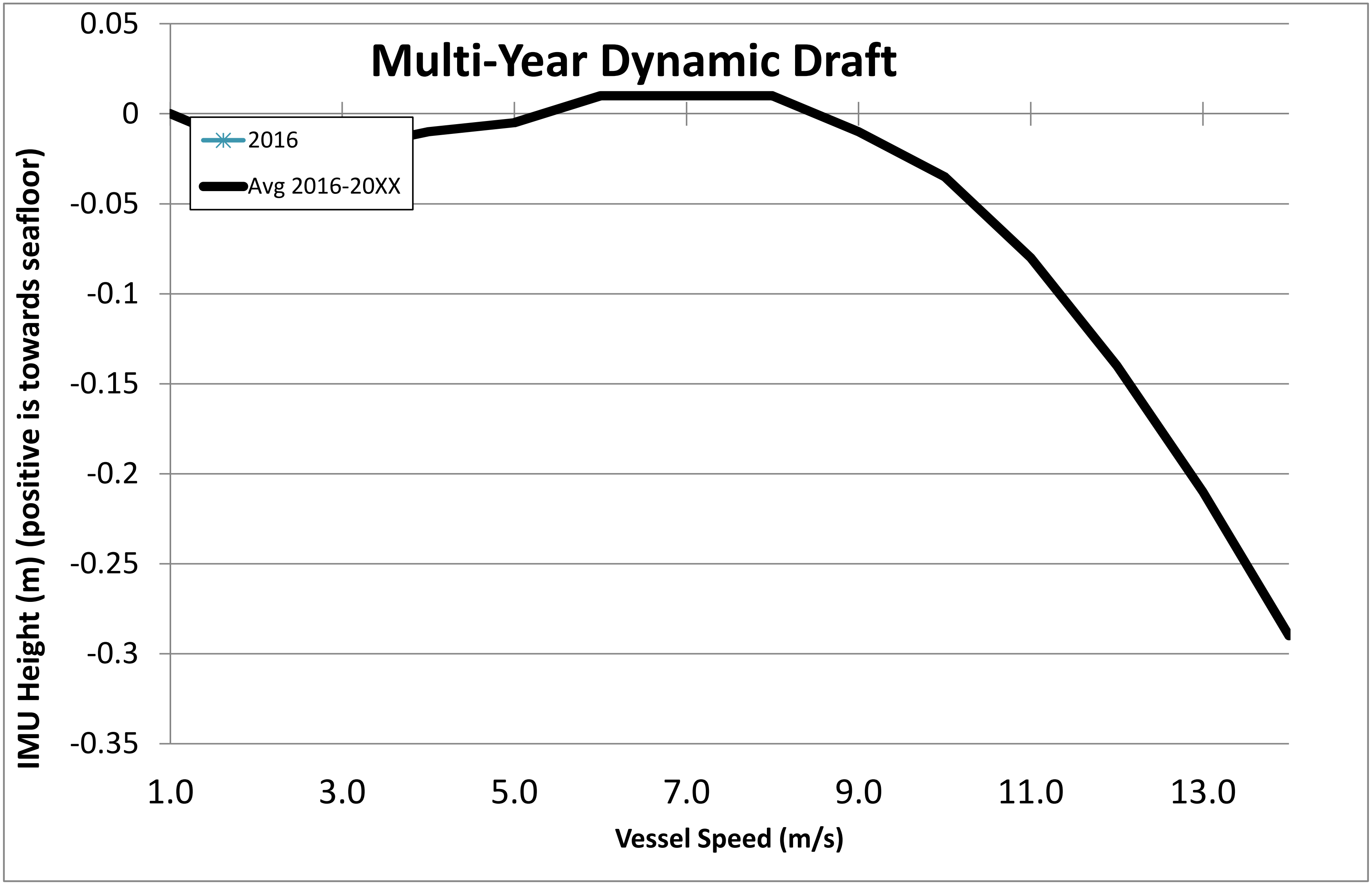
The collected points were referenced to Geodetic Coordinates and needed to be translated to reference the IMU as X=0, Y=0, Z=0. The azimuth from AFT BENCHMARK to FWD BENCHMARK needed to be oriented to 0° 00’ 00” . Post Processing was performed using ForeSight DXM to produce the following Coordinate Report. The X Axis is Positive toward the Bow. The Y Axis is positive toward the Starboard side. The Z Axis is positive downward.

DESCRIPTION	**X (METERS)**	**Y (METERS)**	**Z (METERS)**
IMU	0.000	0.000	0.000
BM AFT	-4.526	-0.005	-0.588
BM PORT	-1.146	-1.168	-0.759
BM STAR	-1.138	1.148	-0.765
PORT GPS ARP	-0.524	-0.522	-2.525
STAR GPS ARP	-2.033	0.560	-2.499
R I	-0.431	0.091	0.469
R II	-0.910	0.097	0.481
R III	0.191	-0.231	0.303
R IV	-1.268	-0.008	-2.040
PLUMB TAPE ON DECK	-1.260	-0.009	-0.112
IMU AFT STAR	-0.072	0.074	-0.002
IMU AFT PORT	-0.069	-0.076	-0.003
IMU FWD PORT	0.053	-0.084	-0.007
IMU FWD STAR	0.050	0.073	-0.007
BM FWD	1.674	-0.005	-0.988
TX	-0.633	0.231	0.403
RX	-0.833	0.237	0.407

2702 - Multi-Year Dynamic Draft Comparison

Speed (m/s)	2016-063	Average 2016-20XX	Std Dev
0.0	0.00	0.00	0.00
0.5	-0.02	-0.02	0.00
1.0	-0.02	-0.02	0.00
1.5	-0.01	-0.01	0.00
2.0	-0.01	-0.01	0.00
2.5	0.01	0.01	0.00
3.0	0.01	0.01	0.00
3.5	0.01	0.01	0.00
4.0	-0.01	-0.01	0.00
4.5	-0.04	-0.04	0.00
5.0	-0.08	-0.08	0.00
5.5	-0.14	-0.14	0.00
6.0	-0.21	-0.21	0.00
6.5	-0.29	-0.29	0.00

2011 and 2012 not used in multi-year average, prior to addition of buoyancy appendages

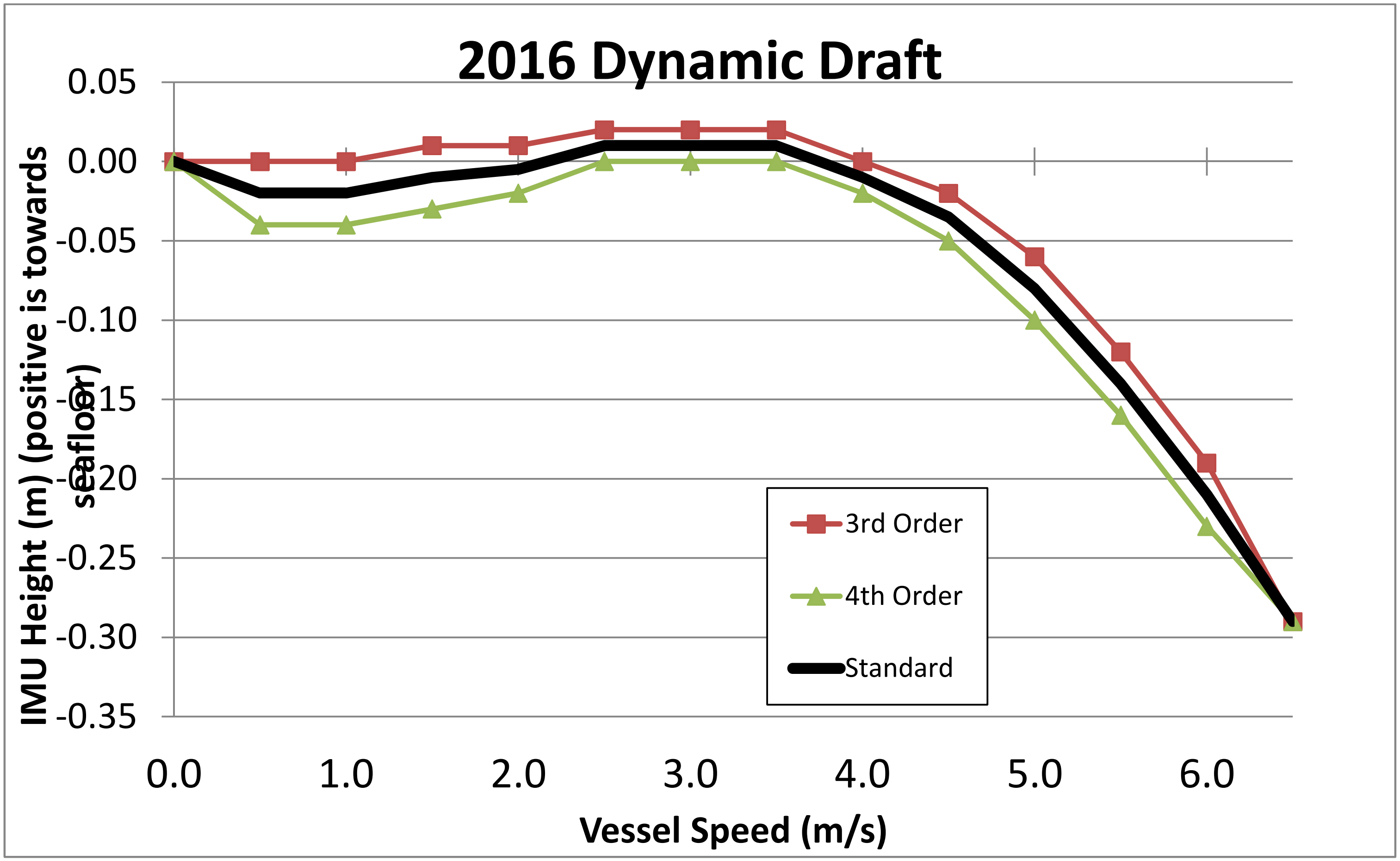

Multi-Year Dynamic Draft
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
IMU Height (m) (positive is towards seafloor)
2016
Avg 2016-20XX
1.0
3.0
5.0
7.0
9.0
11.0
13.0
Vessel Speed (m/s)

2702 - 2016 Elipsoid Referenced Dynamic Draft Results

Trim tabs? Jet bale?

Speed (m/s)	3rd Order	4th Order	Standard
0.0	0.00	0.00	0.00
0.5	0.00	-0.04	-0.02
1.0	0.00	-0.04	-0.02
1.5	0.01	-0.03	-0.01
2.0	0.01	-0.02	-0.01
2.5	0.02	0.00	0.01
3.0	0.02	0.00	0.01
3.5	0.02	0.00	0.01
4.0	0.00	-0.02	-0.01
4.5	-0.02	-0.05	-0.04
5.0	-0.06	-0.10	-0.08
5.5	-0.12	-0.16	-0.14
6.0	-0.19	-0.23	-0.21
6.5	-0.29	-0.29	-0.29

Standard is average of 3rd and 4th order values



2016 Dynamic Draft
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
-0.30
-0.35
IMU Height (m) (positive is towards seafloor)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
Vessel Speed (m/s)
3rd Order
4th Order
Standard

Waterline to IMU Offset

Date: NA **Personnel:** NA
DESIGN DRAFT OF 3.85 METERS

PORT PONTOON Draft Readings

Fwd Outboard	3.85	Fwd Inboard	3.85
Aft Outboard	3.85	Aft Inboard	3.85

Port Ave 3.85

STBD PONTOON Draft Readings

Fwd Inboard	3.85	Fwd Outboard	3.85
Aft Inboard	3.85	Aft Outboard	3.85

Stbd Ave 3.85

Port

Center of IMU Plate to top of IMU	x				
	y				
	z	-0.1356			
IMU Plate to Fwd Outboard 4.6 Draft Mark	x		IMU Plate to Fwd Inboard 4.6 Draft Mark	x	
	y			y	
	z	-3.313 (in CARIS)		z	-3.308 (in CARIS)
IMU Plate to Aft Outboard 4.6 Draft Mark	x		IMU Plate to Aft Inboard 4.6 Draft Mark	x	
	y			y	
	z	-3.306 (in CARIS)		z	-3.305 (in CARIS)

From 2013 Drydock Ave -3.308

4.6

Fwd Outboard Draft Mark to Waterline	x		Fwd Inboard Draft Mark to Waterline	x	
	y			y	
	z	0.750 (in CARIS)		z	0.750 (in CARIS)
Aft Outboard Draft Mark to Waterline	x		Aft Inboard Draft Mark to Waterline	x	
	y			y	
	z	0.750 (in CARIS)		z	0.750 (in CARIS)

Calculated from draft mark 4.6 to draft readings Ave 0.750

IMU to Fwd Outboard Waterline	x		IMU to Fwd Inboard Waterline	x	
	y			y	
	z	-2.427 (in CARIS)		z	-2.422 (in CARIS)
IMU to Aft Outboard Waterline	x		IMU to Aft Inboard Waterline	x	
	y			y	
	z	-2.420 (in CARIS)		z	-2.419 (in CARIS)

Ave -2.694

Stbd

Center of IMU Plate to top of IMU	x				
	y				
	z	-0.1356			
IMU plate to Fwd Inboard 4.6 Draft Mark	x		IMU plate to Fwd Outboard 4.6 Draft Mark	x	
	y			y	
	z	-3.426 (in CARIS)		z	-3.428 (in CARIS)
IMU plate to Aft Inboard 4.6 Draft Mark	x		IMU plate to Aft Outboard 4.6 Draft Mark	x	
	y			y	
	z	-3.344 (in CARIS)		z	-3.358 (in CARIS)

From 2013 Drydock Ave -3.389

Fwd Inboard Draft Mark to Waterline	x		Fwd Outboard Draft Mark to Waterline	x	
	y			y	
	z	0.750 (in CARIS)		z	0.750 (in CARIS)
Aft Inboard Draft Mark to Waterline	x		Aft Outboard Draft Mark to Waterline	x	
	y			y	
	z	0.750 (in CARIS)		z	0.750 (in CARIS)

Calculated from draft mark 4.6 to draft readings Ave 0.750

IMU to Fwd Inboard Waterline	x		IMU to Fwd Outboard Waterline	x	
	y			y	
	z	-2.540 (in CARIS)		z	-2.542 (in CARIS)
IMU to Aft Inboard Waterline	x		IMU to Aft Outboard Waterline	x	
	y			y	
	z	-2.458 (in CARIS)		z	-2.472 (in CARIS)

Ave -2.639

PORT Waterline to Port IMU

Fwd Outboard	2.4274	Fwd Inboard	2.4224	-1
Aft Outboard	2.4204	Fwd Inboard	2.4194	

Port Ave 2.4224

Port Waterline to Port IMU

Waterline to IMU (m)	x	
	y	
	z	2.422
	(In CARIS)	

STBD Waterline to Stbd IMU

Fwd Inboard	2.5404	Fwd Outboard	2.5424	-1
Fwd Inboard	2.4584	Aft Outboard	2.4724	

Stbd Ave 2.5034

Stbd Waterline to Stbd IMU

Waterline to IMU (m)	x	
	y	
	z	2.503
	(In CARIS)	

PORT, STBD Ave
2.463

Date: 6/14/2013 **Personnel:** Adler, Reed, Moehl
Location: MOC-A Port ERLL/WRLL

PORT PONTOON Draft Readings

Fwd Outboard	3.66	Fwd Inboard	3.65
Aft Outboard	3.92	Aft Inboard	3.91

Port Ave **3.785**

STBD PONTOON Draft Readings

Port Fwd Outboard	3.75	Stbd Fwd Outboard	3.59
Port Aft Outboard	3.85	Stbd Aft Outboard	3.78

Stbd Ave **3.743**

Port

Center of IMU Plate to top of IMU	x				
	y				
	z	-0.1675			
IMU Plate to Fwd Outboard 4.6 Draft Mark	x		IMU Plate to Fwd Inboard 4.6 Draft Mark	x	
	y			y	
	z	-3.313		z	-3.308
		(in CARIS)			(in CARIS)
IMU Plate to Aft Outboard 4.6 M Draft Mark	x		IMU Plate to Aft Inboard 4.6 Draft Mark	x	
	y			y	
	z	-3.306		z	-3.305
		(in CARIS)			(in CARIS)

From 2013 Drydock Ave -3.308

Fwd Outboard Draft Mark to Waterline	x		Fwd Inboard Draft Mark to Waterline	x	4.6
	y			y	
	z	0.940		z	0.950
		(in CARIS)			(in CARIS)
Aft Outboard Draft Mark to Waterline	x		Aft Inboard Draft Mark to Waterline	x	
	y			y	
	z	0.680		z	0.690
		(in CARIS)			(in CARIS)

Calculated from draft mark 4.6 to draft readings Ave 0.815

IMU to Fwd Outboard Waterline	x		IMU to Fwd Inboard Waterline	x	
	y			y	
	z	-2.206		z	-2.191
		(in CARIS)			(in CARIS)
IMU to Aft Outboard Waterline	x		IMU to Aft Inboard Waterline	x	
	y			y	
	z	-2.459		z	-2.448
		(in CARIS)			(in CARIS)

Ave -2.661

Stbd

Center of IMU Plate to top of IMU	x				
	y				
	z	-0.1675			
IMU plate to Fwd Inboard 4.6 Draft Mark	x		IMU plate to Fwd Outboard 4.6 Draft Mark	x	
	y			y	
	z	-3.313		z	-3.426
		(in CARIS)			(in CARIS)
IMU plate to Aft Inboard 4.6 Draft Mark	x		IMU plate to Aft Outboard 4.6 Draft Mark	x	
	y			y	
	z	-3.306		z	-3.344
		(in CARIS)			(in CARIS)

From 2013 Drydock Ave -3.347

Fwd Inboard Draft Mark to Waterline	x		Fwd Outboard Draft Mark to Waterline	x	
	y			y	
	z	0.850		z	1.010
		(in CARIS)			(in CARIS)
Aft Inboard Draft Mark to Waterline	x		Aft Outboard Draft Mark to Waterline	x	
	y			y	
	z	0.750		z	0.820
		(in CARIS)			(in CARIS)

Calculated from draft mark 4.6 to draft readings Ave 0.858

IMU to Fwd Inboard Waterline	x		IMU to Fwd Outboard Waterline	x	
	y			y	
	z	-2.296		z	-2.249
		(in CARIS)			(in CARIS)
IMU to Aft Inboard Waterline	x		IMU to Aft Outboard Waterline	x	
	y			y	
	z	-2.389		z	-2.357
		(in CARIS)			(in CARIS)

Ave -2.490

PORT Waterline to Port IMU

Fwd Outboard	2.2055	Fwd Inboard	2.1905	-1
Aft Outboard	2.4585	Fwd Inboard	2.4475	

Port Ave **2.3255**

Port Waterline to Port IMU

Waterline to IMU (m)	x	
	y	
	z	2.326
	(In CARIS)	

STBD Waterline to Stbd IMU

Fwd Inboard	2.2955	Fwd Outboard	2.2485	-1
Fwd Inboard	2.3885	Aft Outboard	2.3565	

Stbd Ave **2.32225**

Stbd Waterline to Stbd IMU

Waterline to IMU (m)	x	
	y	
	z	2.322
	(In CARIS)	

Appendix II

Echosounder Reports

Ferdinand R. Hassler

Multibeam Echosounder Calibration

Ferdinand R. Hassler
Vessel

2/11/2016	042	Chesapeake Bay VA, Cape Charles
Date	Dn	Local Area

Berube, Wilson
Calibrating Hydrographer(s)

Comments

7125 200kHz port	port hull	winter 2015/2016
MBES System	MBES System Location	Date of most recent EED/Factory Check

Sonar Serial Number	Processing Unit Serial Number

TrueHeave filename

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

MVP_2016-02-11_203956

NAV TIME LATENCY

view parallel to track, one line with induced roll (outerbeam) or same lines bounded slope (nadir) [same direction, different speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	2016_0420705	140	6.0	Don't Use
	0721	140	9.0	Don't Use
	2006	320	6.5	
	2018	320	9.0	

PITCH

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

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	2016_0420705	140	6.0	Don't Use
	0712	320	6.0	Don't use
	2006	320	6.5	
	2012	139	6.8	

HEADING/YAW

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

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	2016_0420728	320	6.0	
	0736	140	6.0	
	2023	140	7.0	15 m off line, rerun
	2030	324	7.0	
	2037	136	7.0	rerun 2023

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

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	2016_0420746	050		USE PITCH LINES FOR ROLL
	0754	230		offline; aborted. 10m offset, USE PITCH LINES FOR RO
	0804	230		offline; aborted. 10m offset, USE PITCH LINES FOR RO
	0815			USE PITCH LINES FOR ROLL

Processing Log

Date | Dn | Personnel

☐ Data converted --> HDCS_Data in CARIS

☐ TrueHeave applied

☐ SVP applied

☐ Tide applied

Zone file

Lines merged ☐

Data cleaned to remove gross fliers ☐

Compute correctors in this order			
1. Precise Timing	2. Pitch bias	3. Heading bias	4. Roll bias

Do not enter/apply correctors until all evaluations are complete and analyzed.

PATCH TEST RESULTS/CORRECTORS

Evaluators	Latency (sec)	Pitch (deg)	Roll (deg)	Yaw (deg)
Andvick	0.00	0.36	-0.26	-0.62
Morgan	0.00	0.44	-0.20	-0.65
Berube	0.00	0.45	-0.20	-0.60
Miller	0.00	0.40	-0.22	-0.65
Averages	0.00	0.41	-0.22	-0.63
Standard Deviation	0.00	0.04	0.03	0.02
FINAL VALUES	0.00	0.41	-0.22	-0.63

Final Values based on average

Resulting HVF File Name FH_S250_Port_Reson7125_512bms_200kHz_S7K_2016

MRU Align StdDev gyro 0.02 Value from standard deviation of Heading offset values
MRU Align StdDev Roll/Pitch 0.03 Value from averaged standard deviations of pitch and roll offset values

NARRATIVE

Used the pitch lines for roll because both roll lines that were in the project ran in the same direction (Morgan)

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

Name: Patrick Berube **Date:** 02/19/2016

Ferdinand R. Hassler

Multibeam Echosounder Calibration

Ferdinand Hassler
Vessel

2/11/2016	042	Chesapeake Bay VA, Cape Henry
Date	Dn	Local Area

Berube, Wilson
Calibrating Hydrographer(s)

Comments

7125 Port 400kHz	Port hull	winter 2015/2016
MBES System	MBES System Location	Date of most recent EED/Factory Check

Sonar Serial Number	Processing Unit Serial Number

TrueHeave filename

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

NAV TIME LATENCY

view parallel to track, one line with induced roll (outerbeam) or same lines bounded slope (nadir) [same direction, different speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	2016_0420836	320	6.0	
	0850	140	9.0	offline; aborted
	0859	320	9.0	

PITCH

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

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	2016_0420824	140	6.0	
	0836	320	6.0	

HEADING/YAW

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

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	2016_0420906	140	7.0	not possible to go slower. Aborted line due to offline.
	0919	320	6.0	
	0928	140	7.0	

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

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	2016_0420942	060	6.0	
	0950	240	6.0	

Processing Log

Date	Dn	Personnel

☐ Data converted --> HDCS_Data in CARIS

☐ TrueHeave applied ______

☐ SVP applied ______

☐ Tide applied ______

Zone file ______

Lines merged ☐

Data cleaned to remove gross fliers ☐

Compute correctors in this order			
1. Precise Timing	**2. Pitch bias**	**3. Heading bias**	**4. Roll bias**

Do not enter/apply correctors until all evaluations are complete and analyzed.

PATCH TEST RESULTS/CORRECTORS

Evaluators	Latency (sec)	Pitch (deg)	Roll (deg)	Yaw (deg)
Morgan	0.00	0.65	-0.07	-0.67
Andvick	0.00	0.52	-0.08	-0.23
Berube	0.00	0.66	-0.10	0.05
Miller	0.00	0.60	-0.07	-0.80
Averages	0.00	0.61	-0.08	-0.41
Standard Deviation	0.00	0.06	0.01	0.39
FINAL VALUES	0.00	0.61	-0.08	-0.32

Final Values based on Pitch and Roll used averages. Yaw was a consensus after seeing high std dev.

Resulting HVF File Name FH_S250_PORT_Reson7125_512bms_400kHz_S7K_2016.hvf

MRU Align StdDev gyro	0.39	Value from standard deviation of Heading offset values
MRU Align StdDev Roll/Pitch	0.04	Value from averaged standard deviations of pitch and roll offset values

NARRATIVE

Andvick, Berube, and Morgan looked at Yaw together to come up with consensus due to high std deviation.

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

Name: ______________________ **Date:** __________

Ferdinand R. Hassler

Multibeam Echosounder Calibration

Vessel

Date | Dn | Local Area

Calibrating Hydrographer(s)

Comments

MBES System | MBES System Location | Date of most recent EED/Factory Check

Sonar Serial Number | Processing Unit Serial Number

TrueHeave filename

SV Cast #1 filename | UTC Time | Lat | Lon | Depth | Ext. Depth

SV Cast #2 filename | UTC Time | Lat | Lon | Depth | Ext. Depth

NAV TIME LATENCY view parallel to track, one line with induced roll (outerbeam) or same lines bounded slope (nadir) [same direction, different speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	0531	320	9.0	
	0518	320	6.0	

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

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	2016_042_0512	140	6.0	approx 8m off line
	0518	320	6.0	
	0525	140		approx 10m off line
	0539	140	6.0	approx 8 m line
	0556	140	6.0	

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

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	2016_0420548	320	6.0	
	0604	320	6.0	DO NOT USE - OFF LINE
	0611	140	6.0	

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

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	2016_0420643	050	6.0	
	0650	230	6.0	

Processing Log

Date | Dn | Personnel

☐ Data converted --> HDCS_Data in CARIS

☐ TrueHeave applied ____________________

☐ SVP applied ____________________

☐ Tide applied ____________________

Zone file ____________________

Lines merged ☐

Data cleaned to remove gross fliers ☐

Compute correctors in this order			
1. Precise Timing	2. Pitch bias	3. Heading bias	4. Roll bias
Do not enter/apply correctors until all evaluations are complete and analyzed.			

PATCH TEST RESULTS/CORRECTORS

Evaluators	Latency (sec)	Pitch (deg)	Roll (deg)	Yaw (deg)
Berube	0.00	0.10	0.10	0.55
Morgan	0.00	0.17	0.08	0.28
Andvick	0.00	0.10	0.08	0.61
Miller	0.00	0.15	0.08	0.50
Averages	0.00	0.13	0.09	0.49
Standard Deviation	0.00	0.04	0.01	0.14
FINAL VALUES	0.00	0.13	0.09	0.49

Final Values based on This year's averages

Resulting HVF File Name FH_S250_STBD_Reson7125_512bms_200kHz_S7K_2016.hvf

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

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

NARRATIVE

Did not vary grossly from last year's values

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

Name: ______________________ **Date:** __________

Ferdinand R. Hassler

Multibeam Echosounder Calibration

Ferdinand Hassler
Vessel

2/11/2016	041	Offshore Cape Charles, Chesapeake Bay, VA
Date	Dn	Local Area

Berube, Wilson
Calibrating Hydrographer(s)

Comments

Reson 7125, 400 kHz	Stbd	Winter 2015-2016
MBES System	MBES System Location	Date of most recent EED/Factory Check

Sonar Serial Number	Processing Unit Serial Number

2016_042_S250S.000
TrueHeave filename

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

NAV TIME LATENCY

view parallel to track, one line with induced roll (outerbeam) or same lines bounded slope (nadir) [same direction, different speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	2016_0420308	317	6.0	
	0330	317	9.0	

PITCH

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

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	2016_0420308	317	6.0	
	0319	137	6.0	

HEADING/YAW

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

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	2016_0420338	137	6.0	not sufficient coverage over feature. Will rerun
	0345	317	6.0	not sufficient coverage over feature. Will rerun
	0444			aborted line
	0452	137	6.0	~8 m off line (closer to feature)
	0502	317	6.0	

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

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	20160420353	055	6.0	
	0403	245	6.0	

Processing Log

Date | Dn | Personnel

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

☐ **TrueHeave applied** ______________________

☐ **SVP applied** ______________________

☐ **Tide applied** ______________________

Zone file ______________________

Lines merged ☐

Data cleaned to remove gross fliers ☐

Compute correctors in this order			
1. Precise Timing	**2. Pitch bias**	**3. Heading bias**	**4. Roll bias**
Do not enter/apply correctors until all evaluations are complete and analyzed.			

PATCH TEST RESULTS/CORRECTORS

Evaluators	Latency (sec)	Pitch (deg)	Roll (deg)	Yaw (deg)
Berube	0.00	0.10	0.10	0.72
Morgan	0.00	0.08	0.11	0.43
Andvick	0.00	0.06	0.09	0.79
Miller	0.00	0.00	0.10	0.85
Averages	0.00	0.06	0.10	0.70
Standard Deviation	0.00	0.04	0.01	0.19
FINAL VALUES	0.00	0.06	0.10	0.88

Final Values based on Pitch and Roll use averages. Yaw was consensus of Andvick, Morgan and Berube

Resulting HVF File Name FH_S250_STBD_Reson7125_512bms_400kHz_S7K_2016.hvf

MRU Align StdDev gyro 0.19 Value from standard deviation of Heading offset values

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

NARRATIVE

Morgan's Yaw outlier prompted review. After Andvick, Berube and Morgan reviewed together, 0.88 was consensus.

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

Name: ______________________ **Date:** __________

July 9, 2016

Reference Surfaces

Sonar	Frequency	Line#	Line Azimuth		Sonar
PORT	200 kHz	1911746	360	S-N	PORT
PORT	200 kHz	1911754	180	N-S	PORT
PORT	200 kHz	1911800	360	S-N	PORT
PORT	200 kHz	1911806	180	N-S	PORT
PORT	200 kHz	1911812	360	S-N	PORT
PORT	200 kHz	1911819	270	E-W	PORT
PORT	200 kHz	1911827	90	W-E	PORT
PORT	200 kHz	1911833	270	E-W	PORT
PORT	200 kHz	1911839	90	W-E	PORT
PORT	200 kHz	1911845	270	E-W	PORT

Sonar	Frequency	Line#	Line Azimuth		Sonar
STBD	200 kHz	1912021	180	N-S	STBD
STBD	200 kHz	1912028	360	S-N	STBD
STBD	200 kHz	1912034	180	N-S	STBD
STBD	200 kHz	1912041	360	S-N	STBD
STBD	200 kHz	1912047	180	N-S	STBD
STBD	200 kHz	1912054	270	E-W	STBD
STBD	200 kHz	1912102	90	W-E	STBD
STBD	200 kHz	1912109	270	E-W	STBD
STBD	200 kHz	1912115	90	W-E	STBD
STBD	200 kHz	1912121	270	E-W	STBD

Reference surfaces for all sonars (200/400 KHz port and starboard) completed at

Frequency	Line#	Line Azimuth	
400 kHz	1911905	90	W-E
400 kHz	1911912	270	E-W
400 kHz	1911920	90	W-E
400 kHz	1911926	270	E-W
400 kHz	1911934	90	W-E
400 kHz	1911943	360	S-N
400 kHz	1911950	180	N-S
400 kHz	1911957	360	S-N
400 kHz	1912004	180	N-S
400 kHz	1912010	360	S-N

SV Casts	Time (Local)	Latitude
	1500	
	1845	

Frequency	Line#	Line Azimuth	
400 kHz	1912132	90	W-E
400 kHz	1912139	270	E-W
400 kHz	1912147	90	W-E
400 kHz	1912154	270	E-W
400 kHz	1912200	90	W-E
400 kHz	1912207	0	S-N
400 kHz	1912213	180	N-S
400 kHz	1912219	0	S-N
400 kHz	1912225	180	N-S
400 kHz	1912232	0	S-N

Longitude

Ferdinand R. Hassler

Multibeam Echosounder Calibration

Hassler
Vessel

7/9/2016	191	Rhode Island Sound
Date	Dn	Local Area

Morgan, Marshall, Pye
Calibrating Hydrographer(s)

Comments

Reson 7125/200kHz	Port	
MBES System	MBES System Location	Date of most recent EED/Factory Check

Sonar Serial Number	Processing Unit Serial Number

TrueHeave filename

	15:40:00 AM				
SV Cast #1 filename	UTC Time	Lat	Lon	Depth (m)	Ext. Depth

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

NAV TIME LATENCY

view parallel to track, one line with induced roll (outerbeam) or same lines bounded slope (nadir) [same direction, different speed]

SV Cast #	S7K Line Filename	Heading	Speed (kts)	Remarks
	1911632	025	5.0	PORT 200kHz Nav/Timing
	1911652	025	9.0	PORT 200kHz Nav/Timing

PITCH

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

SV Cast #	S7K Line Filename	Heading	Speed (kts)	Remarks
	1911643	205	9.0	PORT 200kHz Pitch
	1911652	025	9.0	PORT 200kHz Pitch

HEADING/YAW

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

SV Cast #	S7K Line Filename	Heading	Speed (kts)	Remarks

	1911701	205	10.0	PORT 200kHz Yaw
	1911715	205	10.0	PORT 200kHz Yaw/OK line, last one may be best
	1911726	205	10.0	PORT 200kHz Yaw/OK line, last one may be best
	1911739	205	10.0	PORT 200kHz Yaw

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

SV Cast #	S7K Line Filename	Heading	Speed (kts)	Remarks
	1911604	359	9.0	PORT 200kHz Roll
	1911615	179	9.0	PORT 200kHz Roll

Processing Log

7/9/2016	191	Morgan, Pye, Marshall
Date	Dn	Personnel

- [x] **Data converted --> HDCS_Data in CARIS**
- [x] **TrueHeave applied**
- [x] **SVP applied** 2016_July_Patch_Test_S250.svp
- [x] **Tide applied** Predicted: 8452660.tid

Zone file

Lines merged [x]

Data cleaned to remove gross fliers [x]

Compute correctors in this order			
1. Precise Timing	**2. Pitch bias**	**3. Heading bias**	**4. Roll bias**
Do not enter/apply correctors until all evaluations are complete and analyzed.			

PATCH TEST RESULTS/CORRECTORS

Evaluators	Latency (sec)	Pitch (deg)	Roll (deg)	Yaw (deg)
Marshall	0.00	0.49	-0.13	-0.26
Morgan	0.00	0.34	-0.15	-0.15
Blass	0.00	0.40	-0.15	-0.17
Andersen	0.10	0.25	-0.14	-0.28
Averages	0.03	0.37	-0.14	-0.22
Standard Deviation	0.05	0.10	0.01	0.06
FINAL VALUES				

Final Values based on ______________________________

Resulting HVF File Name ______________________________

MRU Align StdDev gyro	0.06	Value from standard deviation of Heading offset values
MRU Align StdDev Roll/Pitch	0.06	Value from averaged standard deviations of pitch and roll offset values

NARRATIVE

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

Name: ______________________________ **Date:** ____________

Ferdinand R. Hassler
Multibeam Echosounder Calibration

Hassler
Vessel

Date	Dn	Local Area
7/9/2016	191	Rhode Island Sound

Calibrating Hydrographer(s): Morgan, Marshall, Pye

Comments:

MBES System	MBES System Location	Date of most recent EED/Factory Check
Reson 7125	Port	

Sonar Serial Number	Processing Unit Serial Number

TrueHeave filename:

	SV Cast filename	UTC Time	Lat	Lon	Depth	Ext. Depth
SV Cast #1						
SV Cast #2		11:40				

NAV TIME LATENCY

view parallel to track, one line with induced roll (outerbeam) or same lines bounded slope (nadir) [same direction, different speed]

SV Cast #	S7K Line Filename	Heading	Speed (kts)	Remarks
	1911312	025	4.0	Do not use/ no s7k/DELETE
	1911329	205	9.0	Do not use/ no s7k/DELETE
	1911413	025	4.0	PORT 400kHz Nav timing
	1911437	025	9.0	PORT 400kHz Nav timing

PITCH

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

SV Cast #	S7K Line Filename	Heading	Speed (kts)	Remarks
	1911426	205	9.0	PORT 400kHz Pitch
	1911437	025	9.0	PORT 400kHz Pitch

HEADING/YAW

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

SV Cast #	S7K Line Filename	Heading	Speed (kts)	Remarks

	1911447	205	9.0	PORT 400kHz Yaw
	1911510	205	9.0	PORT 400kHz Yaw

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

SV Cast #	S7K Line Filename	Heading	Speed (kts)	Remarks
	1911521	359	9.0	PORT 400kHz Roll
	1911532	179	9.0	PORT 400kHz Roll

Processing Log

7/9/2016	191	Morgan, Pye, Marshall
Date	Dn	Personnel

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

☑ **TrueHeave applied**

☑ **SVP applied** 2016_July_Patch_Test_S250.svp

☑ **Tide applied** Predicted: 8452660.tid

Zone file

Lines merged ☑

Data cleaned to remove gross fliers ☑

Compute correctors in this order			
1. Precise Timing	**2. Pitch bias**	**3. Heading bias**	**4. Roll bias**
Do not enter/apply correctors until all evaluations are complete and analyzed.			

PATCH TEST RESULTS/CORRECTORS

Evaluators	Latency (sec)	Pitch (deg)	Roll (deg)	Yaw (deg)
Marshall	0.00	0.25	-0.15 `	-0.36
Pye	0.00	0.34	-0.15	-0.34
Morgan	0.00	0.58	-0.15	-0.26
Andersen	0.00	0.25	-0.13	-0.40
Blass	0.00	0.49	-0.14	-0.46
Averages	0.00	0.38	-0.14	-0.36
Standard Deviation	0.00	0.15	0.01	0.07
FINAL VALUES				

Final Values based on ______________________

Resulting HVF File Name ______________________

MRU Align StdDev gyro	0.07	Value from standard deviation of Heading offset values
MRU Align StdDev Roll/Pitch	0.08	Value from averaged standard deviations of pitch and roll offset values

NARRATIVE

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

Name: ______________________ **Date:** __________

Ferdinand R. Hassler

Multibeam Echosounder Calibration

S250
Vessel

7/9/2016	191	Rhode Island Sound
Date	Dn	Local Area

Morgan, Marshall, Pye
Calibrating Hydrographer(s)

Comments

7125/200kHz	Starboard pontoon	
MBES System	MBES System Location	Date of most recent EED/Factory Check

Sonar Serial Number	Processing Unit Serial Number

TrueHeave filename

	11:15				
SV Cast #1 filename	UTC Time	Lat	Lon	Depth	Ext. Depth
SV Cast #2 filename	UTC Time	Lat	Lon	Depth	Ext. Depth

NAV TIME LATENCY

view parallel to track, one line with induced roll (outerbeam) or same lines bounded slope (nadir) [same direction, different speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	1911200	025	4.0	STBD 200kHz Nav timing
	1911224	025	9.0	STBD 200kHz Nav timing

PITCH

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

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	1911215	205	9.0	STBD 200kHz Pitch
	1911224	025	9.0	STBD 200kHz Pitch

HEADING/YAW

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

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

	1911246	205	9.0	STBD 200kHz Yaw
	1911259	205	9.0	STBD 200kHz Yaw

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

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	1911131	359	9.0	STBD 200kHz Roll
	1911141	179	9.0	STBD 200kHz Roll

Processing Log

7/9/2016	191	Morgan, Pye, Marshall
Date	Dn	Personnel

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

☑ **TrueHeave applied**

☑ **SVP applied** 2016_July_Patch_Test_S250.svp

☑ **Tide applied** Predicted: 8452660.tid

Zone file

Lines merged ☑

Data cleaned to remove gross fliers ☑

Compute correctors in this order			
1. Precise Timing	**2. Pitch bias**	**3. Heading bias**	**4. Roll bias**
Do not enter/apply correctors until all evaluations are complete and analyzed.			

PATCH TEST RESULTS/CORRECTORS

Evaluators	Latency (sec)	Pitch (deg)	Roll (deg)	Yaw (deg)
Pye	0.00	0.25	0.06	0.80
Morgan	0.00	0.33	0.06	0.63
Blass	0.00	0.33	0.06	0.79
Andersen	0.00	0.33	0.07	0.55
Averages	0.00	0.31	0.06	0.69
Standard Deviation	0.00	0.04	0.01	0.12
FINAL VALUES				

Final Values based on __________

Resulting HVF File Name __________

MRU Align StdDev gyro	0.12	Value from standard deviation of Heading offset values
MRU Align StdDev Roll/Pitch	0.02	Value from averaged standard deviations of pitch and roll offset values

NARRATIVE

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

Name: __________ **Date:** __________

Ferdinand R. Hassler

Multibeam Echosounder Calibration

S250
Vessel

7/9/2016	191	Rhode Island Sound
Date	Dn	Local Area

Morgan, Marshall, Pye
Calibrating Hydrographer(s)

Comments

7125 200kHz	Starboard pontoon	
MBES System	MBES System Location	Date of most recent EED/Factory Check

Sonar Serial Number	Processing Unit Serial Number

TrueHeave filename

	8:25				
SV Cast #1 filename	UTC Time	Lat	Lon	Depth	Ext. Depth
	11:15				
SV Cast #2 filename	UTC Time	Lat	Lon	Depth	Ext. Depth

NAV TIME LATENCY

view parallel to track, one line with induced roll (outerbeam) or same lines bounded slope (nadir) [same direction, different speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	1910905	021	4kts	STBD 400khz Slow timing line (recorded on C:)
	1910915			Logging test, discard
	1910930	021	8kts	STBD 400khz pitch/timing combo

PITCH

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

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	1910920	205	8kts	STBD 400khz Pitch line to SW
	1910930	025	8kts	STBD 400khz pitch/timing combo

HEADING/YAW

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

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

	1910942	205	9kts	STBD 400kHz yaw, 13 meters right of track line
	1911010	205	10kts	STBD 400kHz yaw, only partial feature, to be redone
	1911023	205	10kts	STBD 400kHz yaw, call it good

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

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	1911044	359	9kts	STBD 400kHz roll
	1911055	179	10.0	STBD 400kHz roll

Processing Log

7/9/2016	191	Morgan, Pye, Marshall
Date	Dn	Personnel

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

☑ **TrueHeave applied**

☑ **SVP applied** 2016_July_Patch_Test_S250.svp

☑ **Tide applied** Predicted: 8452660.tid

Lines merged ☑

Data cleaned to remove gross fliers ☑

Compute correctors in this order			
1. Precise Timing	**2. Pitch bias**	**3. Heading bias**	**4. Roll bias**
Do not enter/apply correctors until all evaluations are complete and analyzed.			

PATCH TEST RESULTS/CORRECTORS

Evaluators	Latency (sec)	Pitch (deg)	Roll (deg)	Yaw (deg)
Pye	0.00	0.65	0.05	0.76
Blass	0.00	0.50	0.08	0.75
Andersen	0.00	0.70	0.08	0.60
Averages	0.00	0.62	0.07	0.70
Standard Deviation	0.00	0.10	0.02	0.09
FINAL VALUES				

Final Values based on ____________________

Resulting HVF File Name ____________________

MRU Align StdDev gyro	0.09	Value from standard deviation of Heading offset values
MRU Align StdDev Roll/Pitch	0.06	Value from averaged standard deviations of pitch and roll offset values

NARRATIVE

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

Name: ____________________ **Date:** __________

NOAA Ship E.R. Hassler Survey Launch 2702 Report

R2Sonic visited the NOAA Ship E.R. Hassler the week of 16 Nov 2015. This is a brief report on that visit and recommendations to be considered.

The physical installation has the face of the projector even with the face of the receiver. With this orientation it is very important to put the vertical relationship, between the projector's acoustic center and the receiver's acoustic center in the control software. With the standard R2Sonic mounting frame, the vertical relationship between the two acoustic centers is 0.119m. To insure accurate sounding depths, when this vertical distance is changed, it is necessary to measure the new vertical offset and enter the new value in the Projector Z offset (Installation Settings). The measurement resulted in a new Projector Z offset of +0.054m; this was entered into Sonic Control's Installation Settings.

It was brought up, during initial conversations with the survey officer, that the Sonic sonars can work simultaneously with most single beam echosounders such as the navigation echosounder on board the launch. With the frequency agility of the sonar, it is easy to select a frequency that is off the operating frequency or off a harmonic of that frequency. With a 200kHz single beam echosounder, a sonar frequency of 330kHz works very well. On the water, this was tested and proved to be a satisfactory solution and allowed both the navigation echosounder and the multibeam sonar to be operated continuously without any cross talk or interference.

Initially there were issues with providing RTCM or CMR corrections to the Applanix POS MV using the default equipment installed on the survey launch. This did take up the entire first day of operations, but was solved by removing equipment from the Hassler and installing this on the launch and configuring it to output corrections to the POS MV. Once we had accurate positioning, with the POS MV, the GAMS calibration could be completed. We will not go into the GAMS calibration in this document as it is well known to the personnel of NOAA.

One of the prime tasks that R2Sonic wished to complete was an extensive multibeam calibration, better known as the Patch Test. To this end, an area was chosen that historically has been used for calibration and testing.

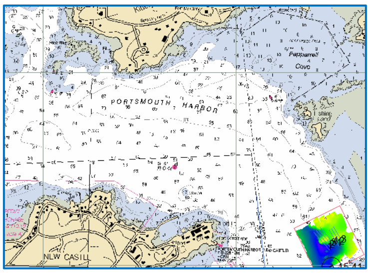


Figure 1: Calibration and test area

A thorough calibration calls for a large data set, for each computation, in order to derive a valid mean and standard deviation. Sea and wind conditions were such that there was some variability in the maneuvering of the vessel. The implication of the variability was that at times, where it was desirable for the sonar head to pass over the same feature, in both directions, the head passed over a slightly different area of the feature. When this occurs, the Yaw computation is very critical for the accuracy of the Pitch computation, even though the Pitch is computed prior to the Yaw solution. If the Yaw is greater than 1.0°, it is advisable to re-compute the Pitch offset using the determined Yaw offset; this was the case with the launch patch test data.

LINES		ROLL	PITCH	Pitch - Yaw adj.	YAW-LINES		YAW
1715	1720	-24.90	N/A	~~0.60~~	1715	1723	1.30
1723	1725	-24.85	0.10	~~0.20~~	1720	1725	1.50
1732	1734	-24.80	-0.10	0.45	1723	1732	1.30
1737	1738	-24.75	N/A	0.45	1725	1734	1.30
1740	1742	-24.85	0.15	0.35	1732	1737	1.10
1802	1804	-24.85	0.20	0.40	1734	1738	0.90
1832	1833	-24.75	0.35	0.50	1832	1840	1.20
1835	1836	-24.75	0.45	0.55	1742	1833	1.20

	Ave.	σ
ROLL	**-24.81**	0.06
PITCH	~~**0.19**~~	0.19
YAW	**1.23**	0.18

Yaw adj Pitch	**0.45**	0.07

As can be seen the final values are: Roll = -24.81°; Pitch = +0.45°; Yaw = +1.23°

Any thorough calibration should be truthed by having the vessel go about a feature in various directions and then comparing each run to see if the feature shifts in any direction. The following day we attempted to perform the truthing survey. Although the data were collected in different directions, over the features of the calibration area, the wind and seas had picked up considerably. This made vessel handling a serious issue, which we attempted to overcome by increase speed. Increasing speed induced squat; no vessel squat data is currently available. Although all cross sections, over the features, showed no horizontal shift, a slight vertical shift was observed. Without squat data or employing RTK heights, the slight vertical shift was attributed to the vessel squat. This is a valid assumption.

It is recommended that as soon as possible a squat determination be made for the launch or that RTK heights be employed to eliminate the effects of squat.

Further, it is recommended that a permanent solution for GPS corrections be found for the POS MV.

Further, it is recommended that a bar check or lead line be performed to verify the surveyed-in offsets on the launch. The adjustment of the Projector Z offset was critical to accurate depths, so is the physical verification of the surveyed-in offsets by either the bar check or lead line methods.

Further, it is recommended, due to the potential change in survey personnel that will be running the launch, that a check list be created that covers all the necessary, preliminary, checks prior to a multibeam survey.

R2Sonic verifies that the 2702 Survey Launch, as far as the Sonic 2022 multibeam is concerned, is survey ready.

Thank you,

C. W. Brennan

Charles W Brennan
R2Sonic LLC

FH 2016 Sidescan Calibration
Side Scan run on Dn068.
Contact is: R"6" Buoy Block Off Duck, NC

MBES Position of Contact

	Lat	Long			
	36.2637083	-75.5936194			
SSS Contacts			Lat Diff (m)	Long Diff (m)	Distance (m)
1	36.2637100	-75.5936370	0.188904001	-1.576896663	1.588171215
2	36.2637150	-75.5936350	0.744504	-1.397703861	1.583623153
3	36.2637210	-75.5936350	1.411224	-1.397703861	1.986234946
4	36.2637100	-75.5936260	0.188904001	-0.591336249	0.620776353
5	36.2637050	-75.5936020	-0.366696	1.558977382	1.60152316
6	36.2637130	-75.5936250	0.522264001	-0.501739848	0.724225491
7	36.2637120	-75.5935710	0.411144	4.336465822	4.355912673
8	36.2636760	-75.5936040	-3.589176	1.37978458	3.845255498
9	36.2636940	-75.5936250	-1.589016	-0.501739848	1.666347719
10	36.2637250	-75.5936180	1.855704	0.125434961	1.859938511
11	36.2637410	-75.5936120	3.633624001	0.66301337	3.693617482
12	36.2636710	-75.5936290	-4.144775999	-0.860125454	4.233082078
13	36.2637070	-75.5936580	-0.144456	-3.458421091	3.461436693

N	13	Average	-0.067526769	-0.170922366	2.401549613	-0.11922457
DOF: 2N-1	25	StDev	2.089422731	1.896534039		1.955707889

Criteria: 95% Confidence that any future measurement will not give a positional error greater than 10 meters.

Assuming x and y errors are goverened by the same normal distribution, the square of the distance error is governed by Chi-squared statistics.

So:

$$\boxed{P\left[d^2 > \frac{\sigma^2 \chi^2_{n;\alpha}}{n}\right] = \alpha}$$

Setting the distance error equal to 10 meters and using the Chi-squared value for one degree of freedom and alpha = 0.05, solve for the maximum value for the true value of the standard deviation of the x and y error.

Distance Error Limit (meters)	10
Max. x,y Std Deviation	5.1

The sample estimate of the standard deviation will also be Chi-squared distributed

At a 95% confidence interval the standard deviation range is:

	low	best est.	high	
x,y StDev	1.5	2.0	2.7	
And the 95% confidence inteval of the positioning error is:				
Error	3.0	3.8	5.3	**PASS**

Note: FPM method of 1.96*RMS standard deviation

Error: 5.530718786 **PASS**

Appendix III

Positioning and Attitude System Reports

POSMV 320
INSTALLATION REPORT

Prepared for NOAA
Ferdinand Hassler
S250 SWATH
May, 2011
By

Bruce A. Francis
Applanix
Houston, TX

Company:	**Oak Management**	
Attention of:	**Steve Laverty**	
Email:	steve.laverty@oakmanagement.com	
From:	Bruce A. Francis	
Date:	18 May, 2011	
Ref.:	**POSMV Installation aboard** ***Ferdinand Hassler-SWATH***	

Bruce A. Francis
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http://www.applanix.com

During the period of May16th to May 18th, 2011 two POSMV systems were commissioned aboard NOAA vessel *Ferdinand Hassler*. The following is a summary of the events and final observations.

Chronology:

May 16th-

Travel from Houston TX to New Orleans LA. Overnight in Gulfport MS with the intention of meeting the ship in the morning to conduct dockside testing in the morning before the ship sets sail in the afternoon. Informed by Steve Laverty there has been a change in plan and the CO wants to depart the dock at 0900 tomorrow instead.

May 17th-

Arrive ship 0730. Brief review of POSMV installation with Briana Welton followed by cursory inspection. Both POSMV systems are up and running with no errors. Collected a set of dockside POSMV data from both systems for processing in POSPAC later today. Plan is to meet at the NOAA facility in Pascagoula at 0630 and transit out to ship in small boat.

May 18th- 0630- Depart Pascagoula for Ferdinand Hassler. Upon arrival commenced system inspection and diagnostics. No faults found. Conducted two GAMS calibrations on both POSMV systems and completed system acceptance testing.

Calibration and testing results:

1. The GAMS calibration was completed on May 18th and checked against the calculations derived from the survey report. Further comparisons are required but it appears that the survey calculations differ somewhat from the GAMS measured values.

Notes:

As a result of post processing the data set collected during commissioning, it was discovered that the POSMV IMU's were actually reversed at the back of the POSMV PCS units. Because of the symmetry in the two systems, these errors were not immediately obvious during the trials; however the lever arm errors were apparent in the data set. After physically changing the IMU inputs the processed calibration data was now reasonable when compared to the measured survey results. A new GAMS calibration was performed by the NOAA personnel after the IMU cables were returned to the correct orientation and the information below is based upon the correct orientation.

Recommendations:

While the large separation between the GPS antennas across decks will improve heading accuracy, there is a possibility that flexure in the ship will cause poor GAMS performance as the baseline vectors may become unstable. We were unable to fully test this configuration in a calm sea but if this turns out to be the case after the ship experiences a modest increase in sea state, the solution might be to extend the separation between the antennas on the individual mounts and switch the antenna input to the POS from cross decks to using the pairs from each side to their corresponding POS unit. The minimum separation should be 1 meter whereas now the distance is only about 0.6m and slightly too short to expect normal GAMS performance.

Submitted By:
Bruce A. Francis
Customer Support Engineer
Marine Products
713-896-9900
bfrancis@applanix.com

Vessel Name	Ferdinand R. Hassler
Year Built	2010
POSMV Location	**Port Side**
PCS Serial Number	3187
IMU Serial Number Top Hat	804 (Cable S/N 105)
Hardware Version	3.3-7
Firmware Version	5.03
POS IP Address Subnet Mask	129.100.2.231 255.255.0.0
POS PC Address Subnet Mask	129.100.2.234 255.255.255.0
Survey Software	Hypack 11.0.8.0
Multibeam System	Reson 7125

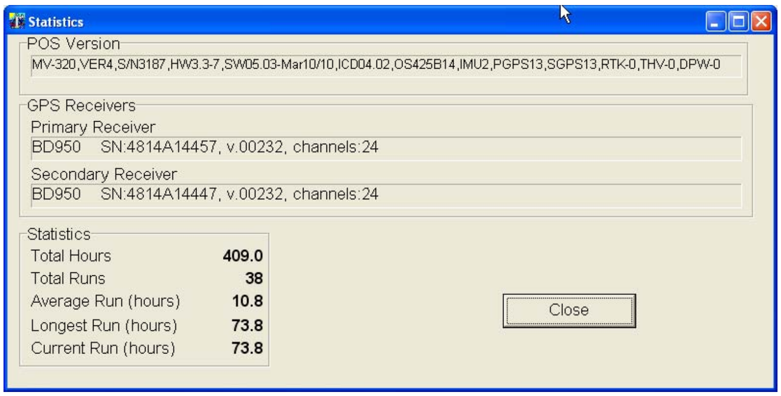
Port System Lever Arms: (Units are in Meters)

Point	**X Axis**	**Y Axis**	**Z Axis**	**Notes**
Reference point	0.0	0.0	0.0	PORT IMU
Ref to IMU	0.0	0.0	0.0	PORT IMU
Ref to Primary GPS	1.395	1.05	-13.084	Port Aft antenna
Ref to Secondary GPS	1.418	9.188	-13.080	Strb Aft antenna
Ref to AUX GPS	N/A	N/A	N/A	Not surveyed
Ref to Vessel	0.0	0.0	0.0	POS NMEA, message point of validity at target on IMU.
IMU frame w.r.t Ref frame	0.0	0.0	0.0	Rotation of IMU frame in comparison to ships frame.
Ref to Heave (COR)	0.0	0.0	0.0	Center of gravity (rotation) Information not available.
Ref to Sensor 1	0.0	0.0	0.0	Point of validity of HPR +Posn-Valid at IMU
Ref to Sensor 2	0.0	0.0	0.0	Point of validity-HPR +Posn-Valid at IMU

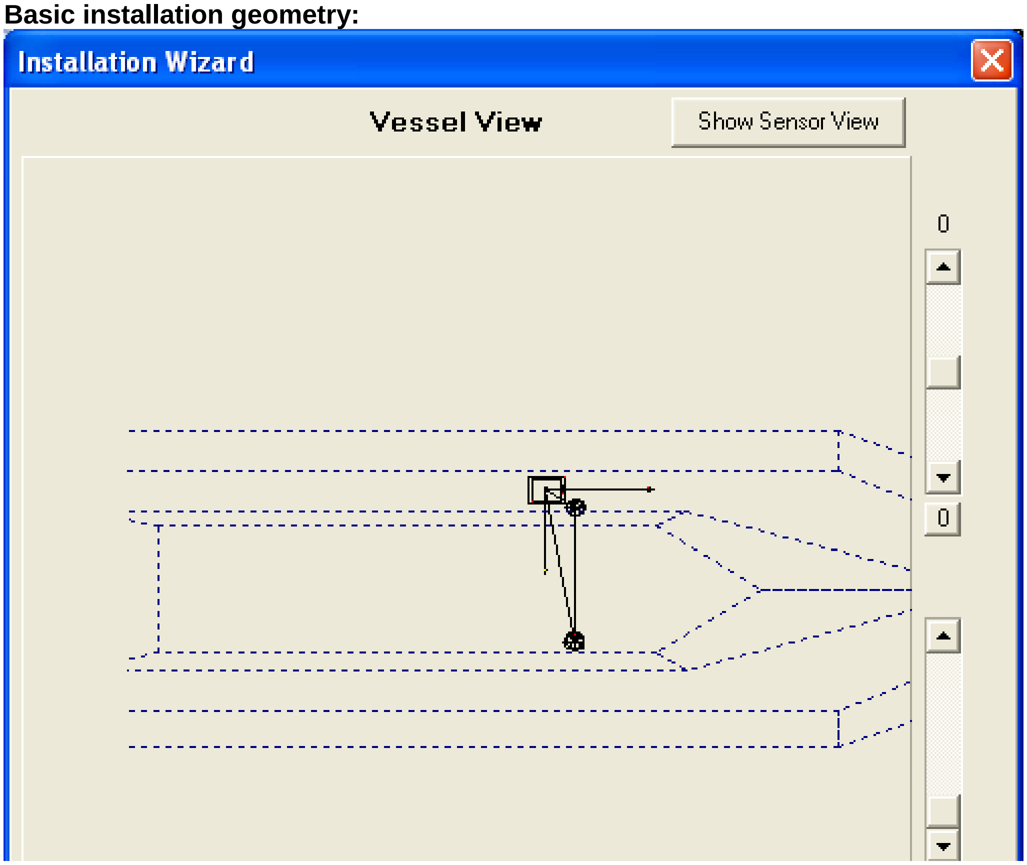
General System information:

Options included- RTK (RTK-0); True Heave (THV-0); (DPW-0) Password protection Disabled

Port POSMV



Basic installation geometry:

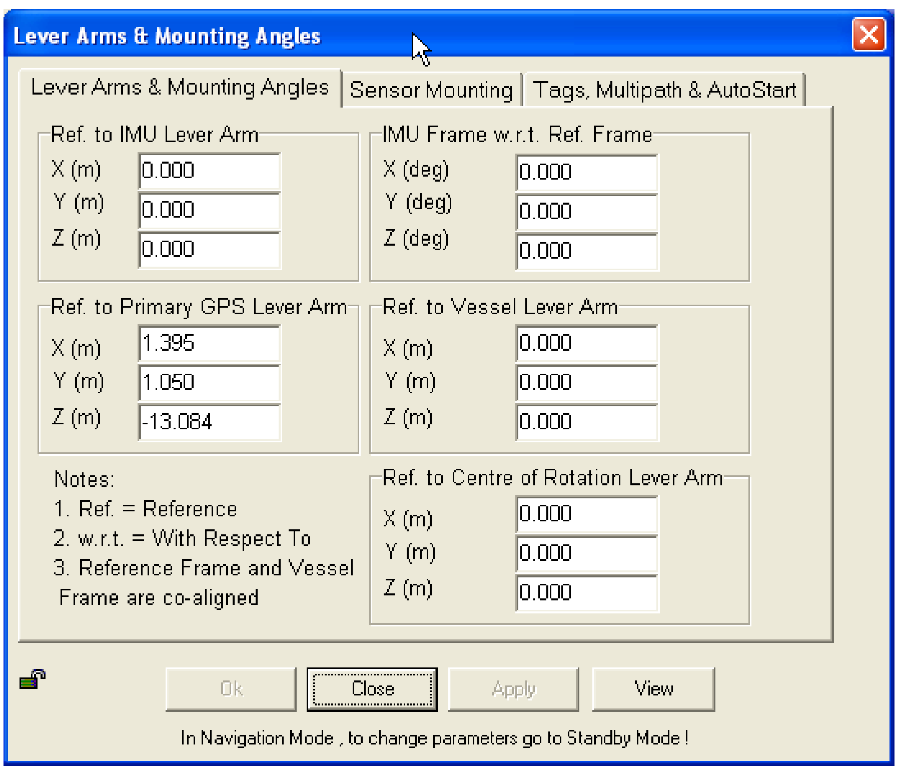


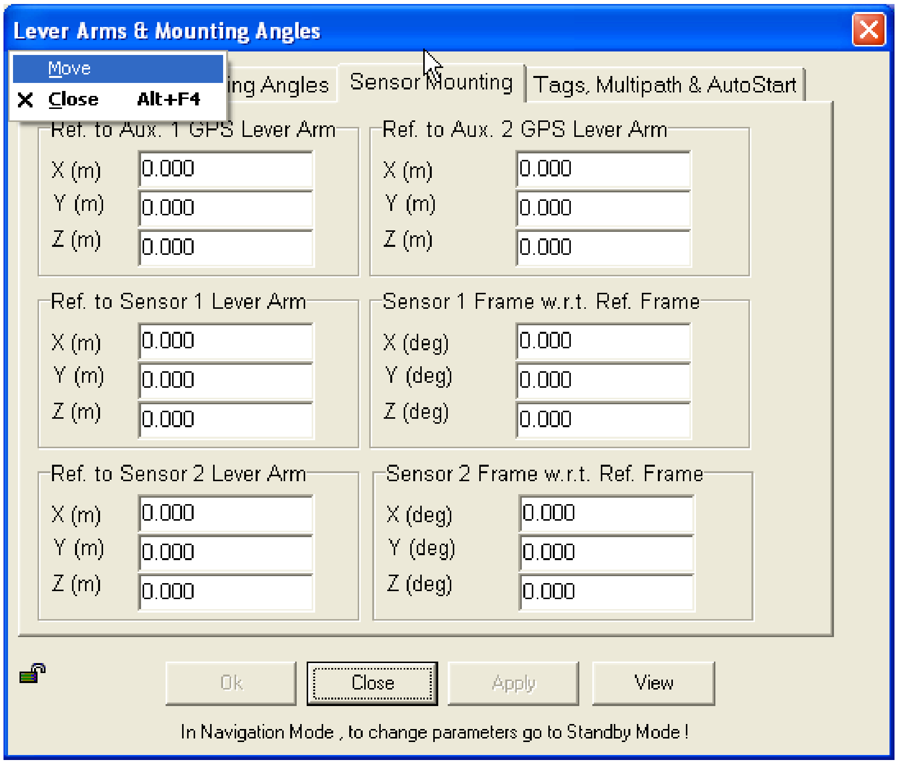
```
POSRT Data Extraction Utility [Jun 15 2011]
Copyright (c) 2008-2011 Applanix Corporation.  All rights reserved.
Date : 07/25/11    Time : 15:12:36
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
First POS file      : E:\Clients config, IP, & test results\NOAA\NOAA
Swath\Final_Data_IMUcorrect\For Bruce Frances\2011_152_S250_Port_A_GAMS.000
Last POS file       : E:\Clients config, IP, & test results\NOAA\NOAA
Swath\Final_Data_IMUcorrect\For Bruce Frances\2011_152_S250_Port_A_GAMS.000
Output path         : C:\Documents and Settings\bfrancis\My Documents\POSPac
MMS\Unnamed(1)\Swath Port IMU\Extract
Output kernel       : Swath Port IMU
Start time          : 0.000
End time            : 999999.000
VNAV output modulus : 1
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
307750.275 : The First Group 99: Versions & Statistics
   System Version:
     Product-Model: MV-320; Version: VER4; Serial Number: S/N3187;
     Hardware Version: HW3.3-7;
     Software Release Version-Date: SW05.03-Mar10/10;
     ICD release version: ICD04.02;
     Operating System Version: OS425B14;
     IMU Type: IMU2; Primary GPS Type: PGPS13; Secondary GPS Type: SGPS13;
     Option mnemonic-Expiry Time: DMI0;
     Option mnemonic-Expiry Time: GIM0;
     Option mnemonic-Expiry Time: RTK-0;
     Option mnemonic-Expiry Time: THV-0;
     Option mnemonic-Expiry Time: DPW-0;
   Primary GPS Version: BD950        SN:4814A14457, v.00232, channels:24;
   Secondary GPS Version: BD950      SN:4814A14447, v.00232, channels:24;
   Total Hours          :    561.4; Number of Runs:     53
   Average Length of Run:   10.6; Longest Run:  126.2; Current Run:   12.1;
--------------------------------------------------------------------------------
307750.275 : Diffcorr2 time1 gap: start 0.0, end 307750.2749
307750.280 : IMU type: IMU2  Data rate = 200 Hz
307750.280 : Extracting Group 4 : Time-tag data
307750.290 : SNV status changed to 0  (Full Nav)
307751.070 : Primary GNSS receiver type is GNSS13.
307751.090 : Secondary GNSS receiver type is GNSS13.
307755.275 : GenB( 9):  GAMS solution in use CLEARED.
307756.275 : GenB( 9):  GAMS solution in use SET.
307758.275 : GenB( 9):  GAMS solution in use CLEARED.
--------------------------------------------------------------------------------
307759.275 : Message 50: Transition to NAVIGATE mode.
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
307759.275 : Message 37: Base 1 setup
   Input data type expected: RTCM 1 or 9
   Datum Type: NAD83
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
307759.275 : Message 38: Base 2 setup
   Input data type expected: RTCM 1 or 9
   Datum Type: WGS84
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
307759.275 : Message 20: General parameters
   Time and distance tag types:          2  1
   Autostart selection:                   ENABLED
   Reference-IMU lever arm:              -0.008  -0.031  0.130
   Reference-primary GPS lever arm:      1.395  1.050  -13.084
   Reference-auxiliary 1 GPS lever arm:  0.000  0.000  0.000
```

```
   Reference-auxiliary 2 GPS lever arm:  0.000  0.000  0.000
   Reference-IMU mounting angles:        0.000  0.000  0.000
   Reference-vehicle mounting angles:    0.000  0.000  0.000
   Multipath environment:                 LOW
--------------------------------------------------------------------------------

--------------------------------------------------------------------------------
307759.275 : Message 22: Aiding sensor install parameters
   DMI scale factor:                    0.00
   Reference-DMI lever arm:             0.00    0.00    0.00
   DVS scale factor correction:         1.00
   Reference-DVS lever arm:             0.00    0.00    0.00
   Reference-DVS attitude:              0.00    0.00    0.00
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
307759.275 : Message 24: User accuracy parameters
   User position accuracy:       2.00
   User velocity accuracy:       0.50
   User attitude accuracy:       0.05
   User heading accuracy:        0.05
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
307759.275 : Message 106: Heave ratios
   Heave Bandwidth (sec):  12.000
   Heave Damping Ratio:  0.707
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
307759.275 : Message 120: Heave and sensor 1&2 install parameters
   Reference->Sensor1 alignment angles (R,P,Y) in degrees:  0.00  0.00  0.00
   Reference->Sensor2 alignment angles (R,P,Y) in degrees:  0.00  0.00  0.00
   Reference->Sensor1 lever arm in meters:                  0.00  0.00  0.00
   Reference->Sensor2 lever arm in meters:                  0.00  0.00  0.00
   Reference->Center of Rotation in meters:                    0.00  0.00  0.00
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
307759.275 : Message 121: Vessel Installation Parameters
   Reference-Vessel in meters:                             0.00  0.00  0.00
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
307759.275 : Message 32: PCS IP address
   IP Address (Network part 1): 129
   IP Address (Network part 2): 100
   IP Address (Host part 1):    1
   IP Address (Host part 2):    232
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
307759.275 : Message 56: General data
   Initial status:     COARSE_LEVEL
   Initial position:   30.339734242 -88.576108929 -24.927
   Initial distance:   0.00
   Initial attitude:   0.000 0.000 0.000
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
307759.275 : Message 21: GAMS install parameters
   A-B antenna separation:        8.112
   A-B baseline vector:           -0.060 8.112 0.021
   Heading error for calibration: 0.50
   A-B azimuth correction:        0.000
--------------------------------------------------------------------------------
Available subsystems                  :  IMU
                                      :  Primary GNSS
                                      :  Secondary GNSS
                                      :  Differential Corrections
Vehicle to reference alignment angles :  0.000  0.000  0.000
Multipath setting                     :  LOW
Reference to IMU lever arm            : -0.008 -0.031  0.130
Reference to IMU alignment angles     :  0.000  0.000  0.000
Reference to primary GNSS lever arm   :  1.395  1.050 -13.084
GAMS antenna separation               :  8.104
GAMS baseline vector                  :  0.152  8.103 -0.004
```

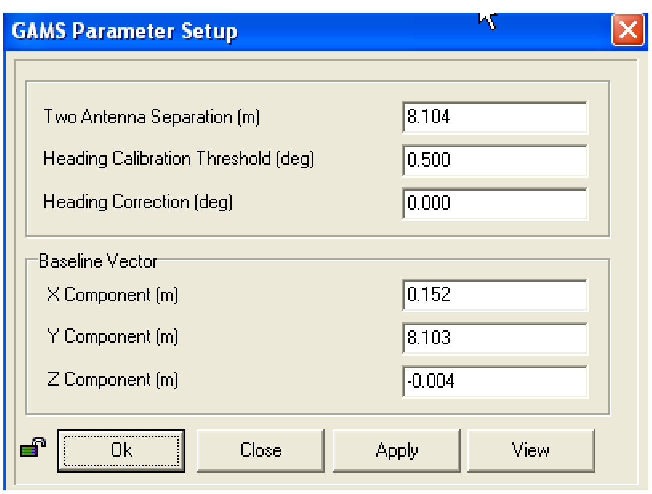
```
GAMS heading calibration threshold    :  0.500
GAMS heading correction               :  0.000
```



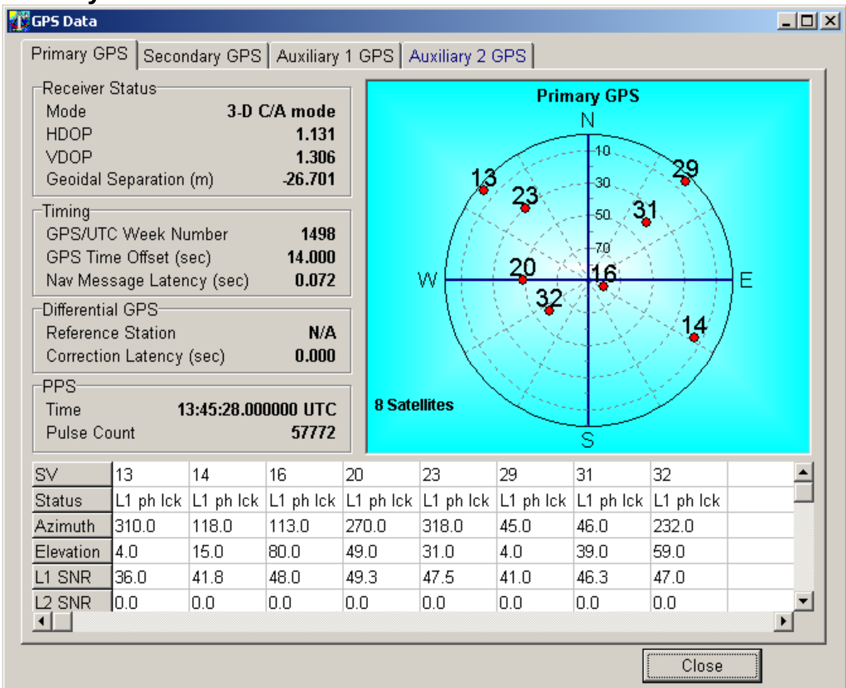


Observed GAMS values derived from the field calibration:

Port GAMS Cal #1

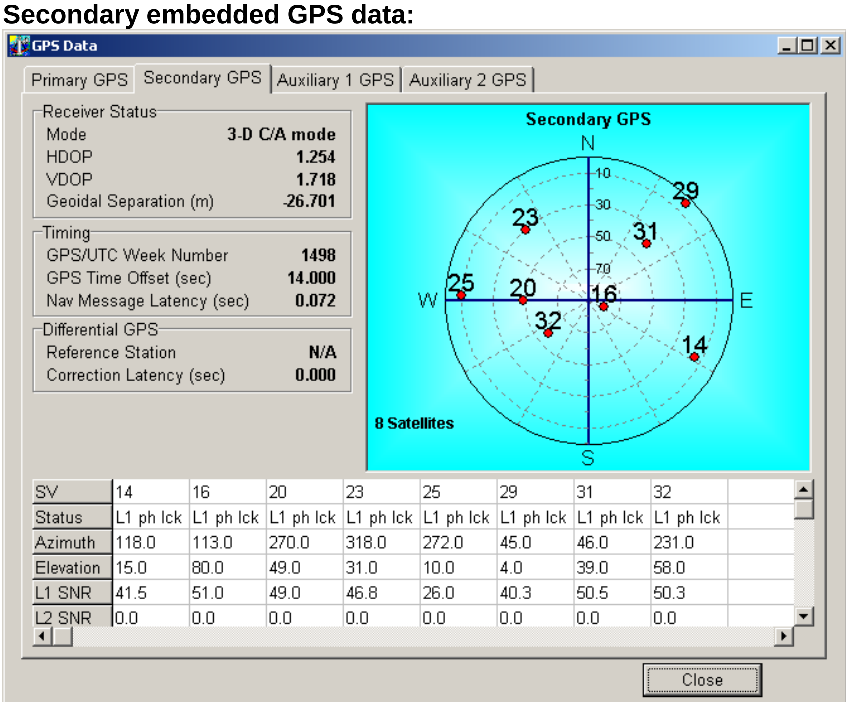


Primary GPS data observed from internal Trimble BD950 receivers.



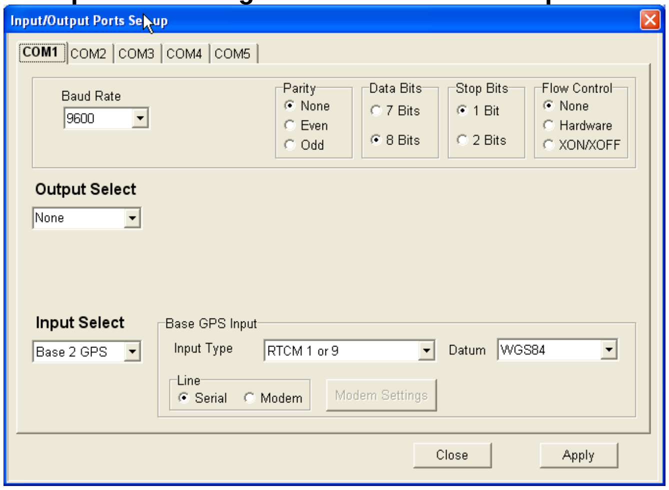
SV	13	14	16	20	23	29	31	32
Status	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck
Azimuth	310.0	118.0	113.0	270.0	318.0	45.0	46.0	232.0
Elevation	4.0	15.0	80.0	49.0	31.0	4.0	39.0	59.0
L1 SNR	36.0	41.8	48.0	49.3	47.5	41.0	46.3	47.0
L2 SNR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Secondary embedded GPS data:

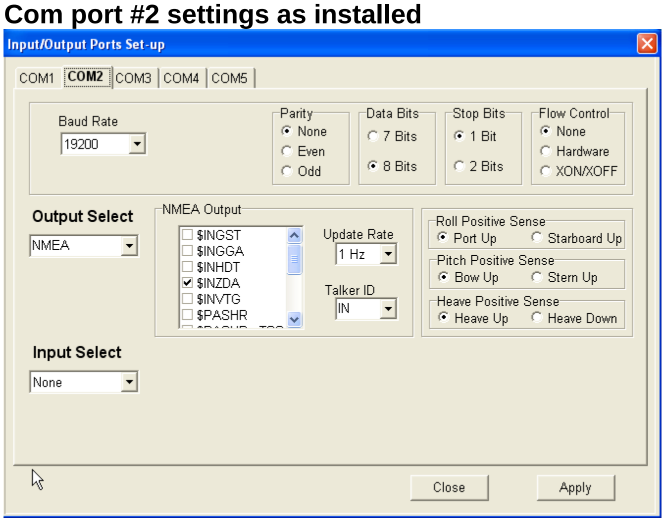


SV	14	16	20	23	25	29	31	32
Status	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck
Azimuth	118.0	113.0	270.0	318.0	272.0	45.0	46.0	231.0
Elevation	15.0	80.0	49.0	31.0	10.0	4.0	39.0	58.0
L1 SNR	41.5	51.0	49.0	46.8	26.0	40.3	50.5	50.3
L2 SNR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

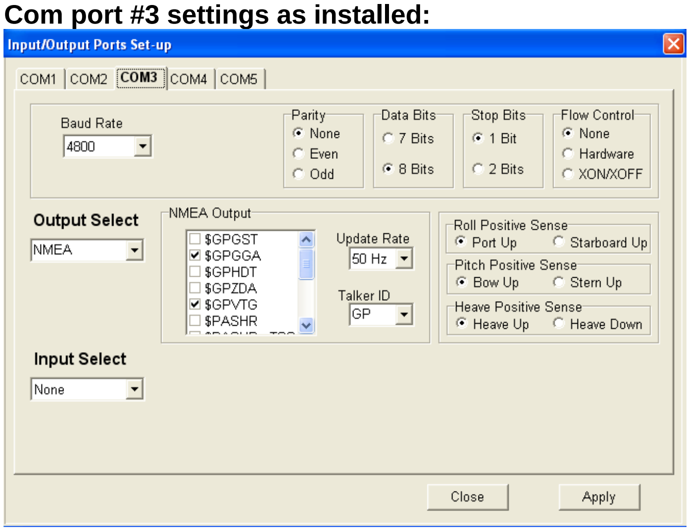
Com port #1 settings as installed: DGPS input from Trimble SPS Receiver.



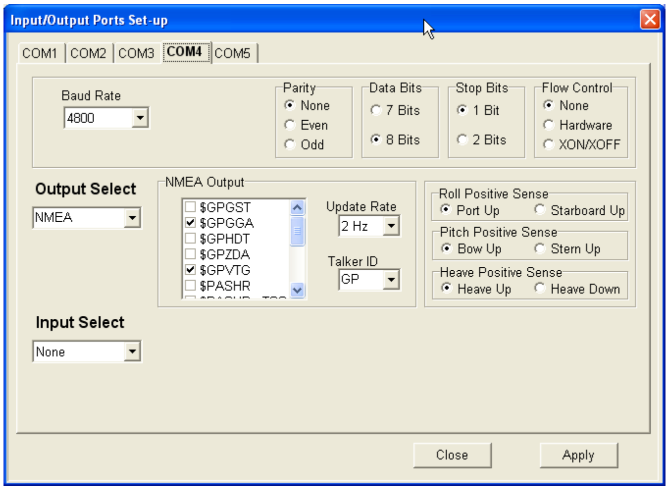
Com port #2 settings as installed



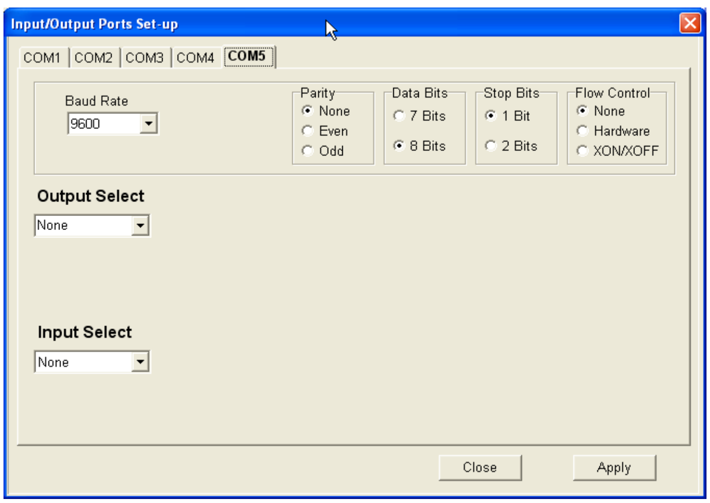
Com port #3 settings as installed:



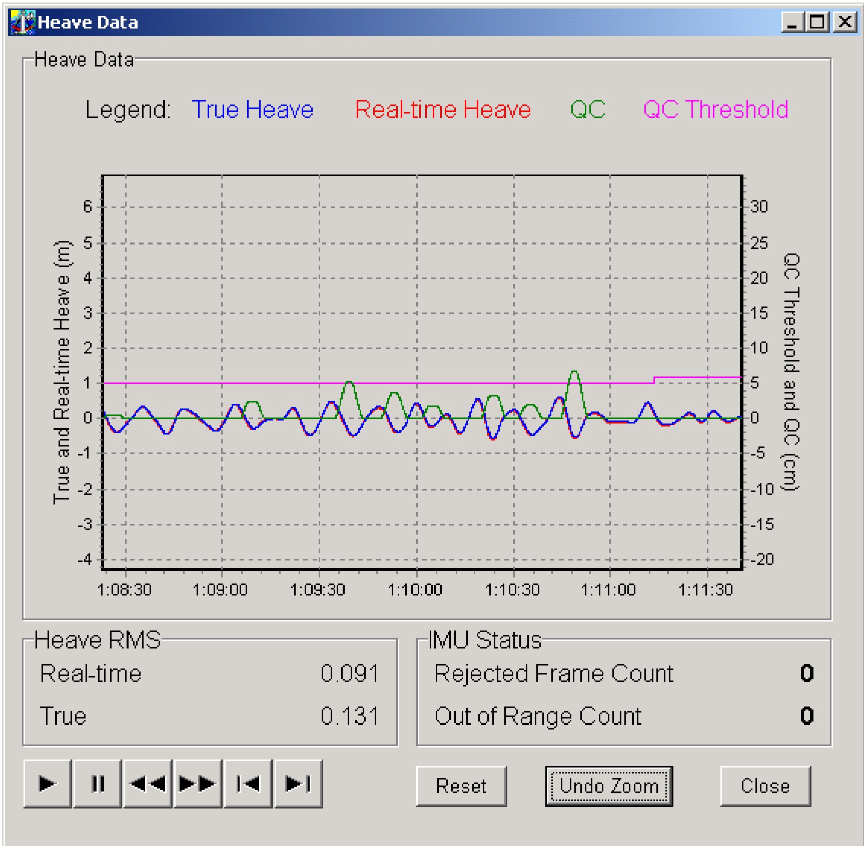
Com port #4 settings as installed:



Com port #5 settings as installed

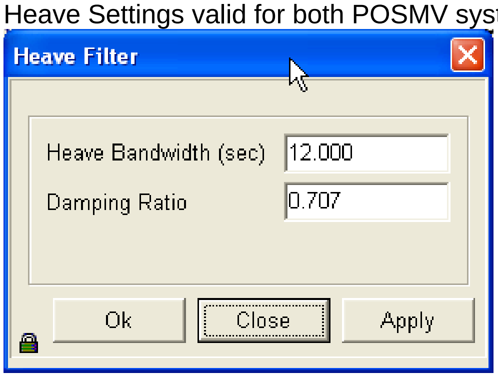


Heave data plot:

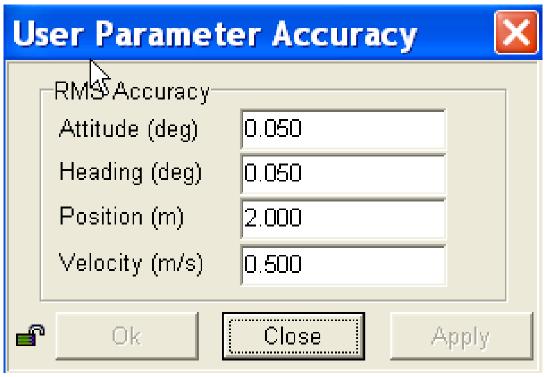


The heave plot above shows the relationship between the Real-time (RT) heave and the True (or delayed TH) heave measurements. The green line relates to quality control (QC) and represents the difference between the two values. When the delta between the RT and TH exceeds 5cm or 5% of total heave (pink line) then the radio light on the main controller screen will turn from green to red but <u>does not affect the real-time heave data being collected</u>. Quite often this occurs after the vessel makes a turn or an abrupt change in speed and is not necessarily cause for alarm. The heave filter has a 105 second buffer so the event which may have caused the impulse happened in the past. A red light merely calls the users attention to the difference and may also suggest that the filter settings need to be refined if the QC value is continually out of bounds.

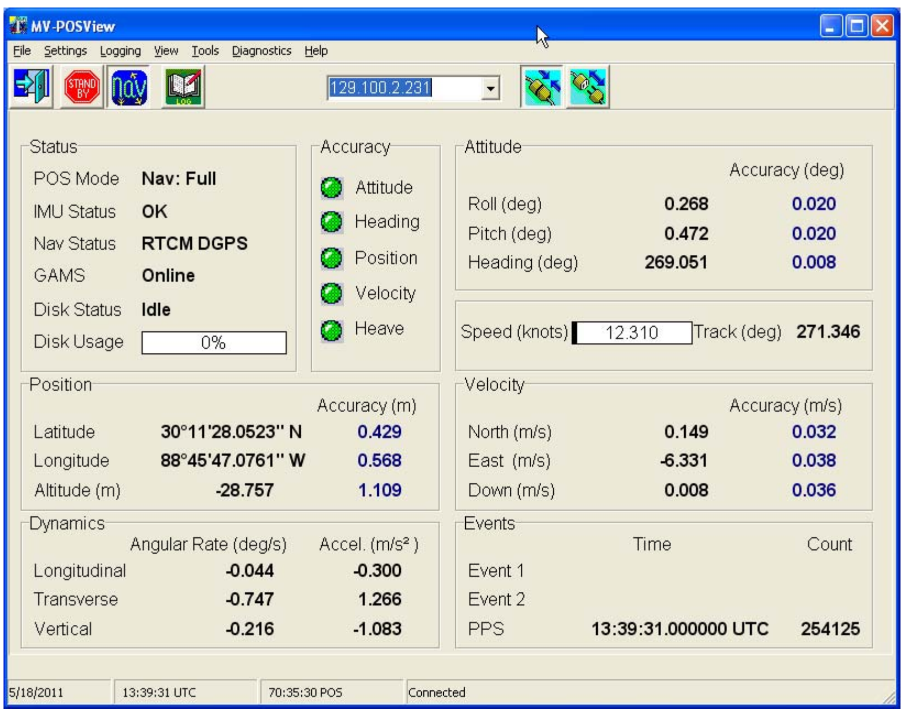
Note: The TrueHeave data filter is delayed about 3 minutes from the TH value. <u>Also, Group 111 & 113 must be enabled in the Ethernet Real-time logging page.</u> In addition, this filter should be adjusted as required for changes in the local swell conditions.
Heave Settings valid for both POSMV systems.



The main controller screens below shows normal POSMV operation. POS Mode is FULL indicating that all user accuracy settings have been satisfied. Note, when using RTK the position threshold should be set to a smaller value i.e. 0.100m or whatever is specified in the survey parameters. Exceeding any of the limits below will cause one of the radio lights to turn red and the POS mode will no longer report "Full Navigation" This however only affects the flag in the GGA or GGK message and not the performance.



Port POSMV Final Navigation



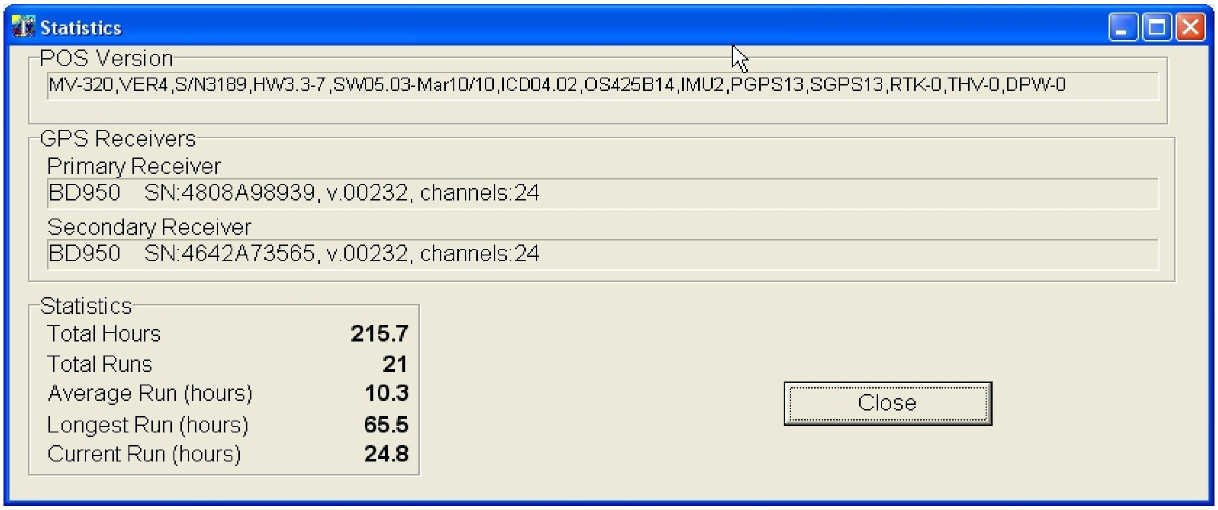
Port side antenna and IMU mounting:

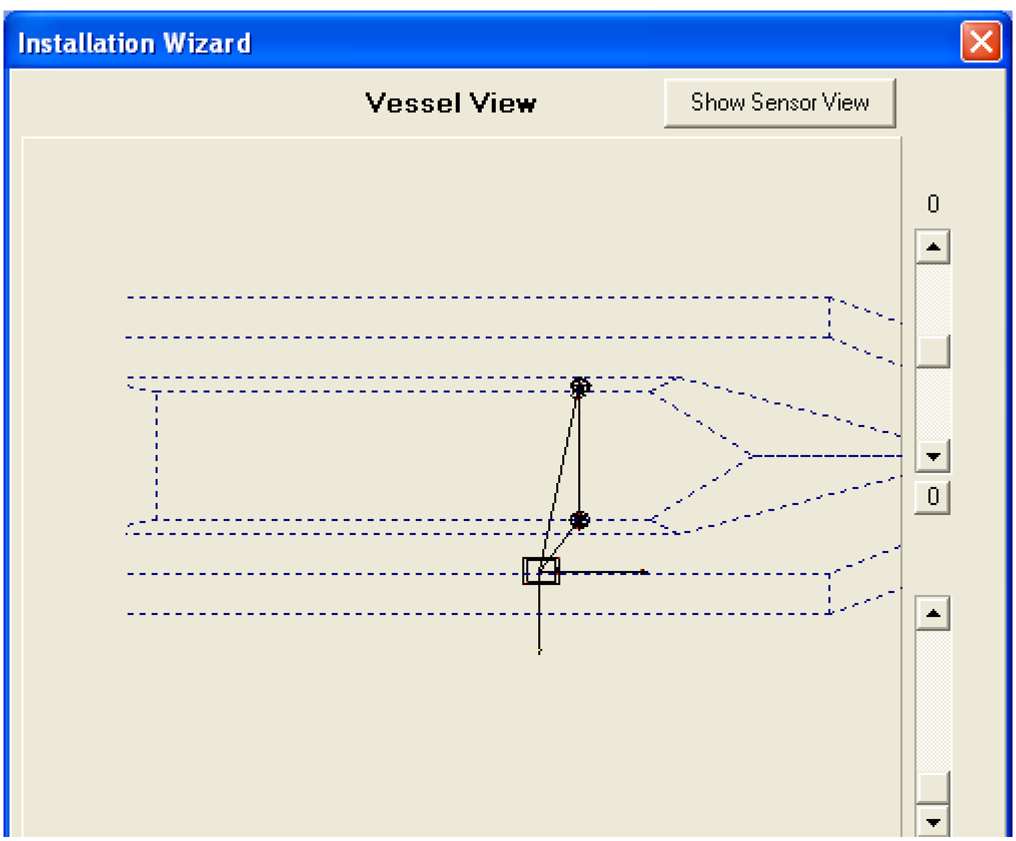
Vessel Name	Ferdinand R. Hassler
Year Built	2010
POSMV Location	**STRB Side**
PCS Serial Number	3189
IMU Serial Number Top Hat	803 (Cable S/N 104)
Hardware Version	3.3-7
Firmware Version	5.03
POS IP Address Subnet Mask	129.100.1.231 255.255.0.0
POS PC Address Subnet Mask	129.100.1.234 255.255.255.0
Survey Software	Hypack 11.0.8.0
Multibeam System	Reson 7125

Port System Lever Arms: (Units are in Meters)

Point	**X Axis**	**Y Axis**	**Z Axis**	**Notes**
Reference point	0.0	0.0	0.0	STRB IMU
Ref to IMU	0.0	0.0	0.0	STRB IMU
Ref to Primary GPS	1.929	-11.199	-13.084	Port FWD antenna
Ref to Secondary GPS	1.953	-3.056	-13.083	Strb FWD antenna
Ref to AUX GPS	N/A	N/A	N/A	Not surveyed
Ref to Vessel	0.0	0.0	0.0	POS NMEA, message point of validity at target on IMU.
IMU frame w.r.t Ref frame	0.0	0.0	0.0	Rotation of IMU frame in comparison to ships frame.
Ref to Heave (COR)	0.0	0.0	0.0	Center of gravity (rotation) Information not available.
Ref to Sensor 1	0.0	0.0	0.0	Point of validity of HPR +Posn-Valid at IMU
Ref to Sensor 2	0.0	0.0	0.0	Point of validity-HPR +Posn-Valid at IMU

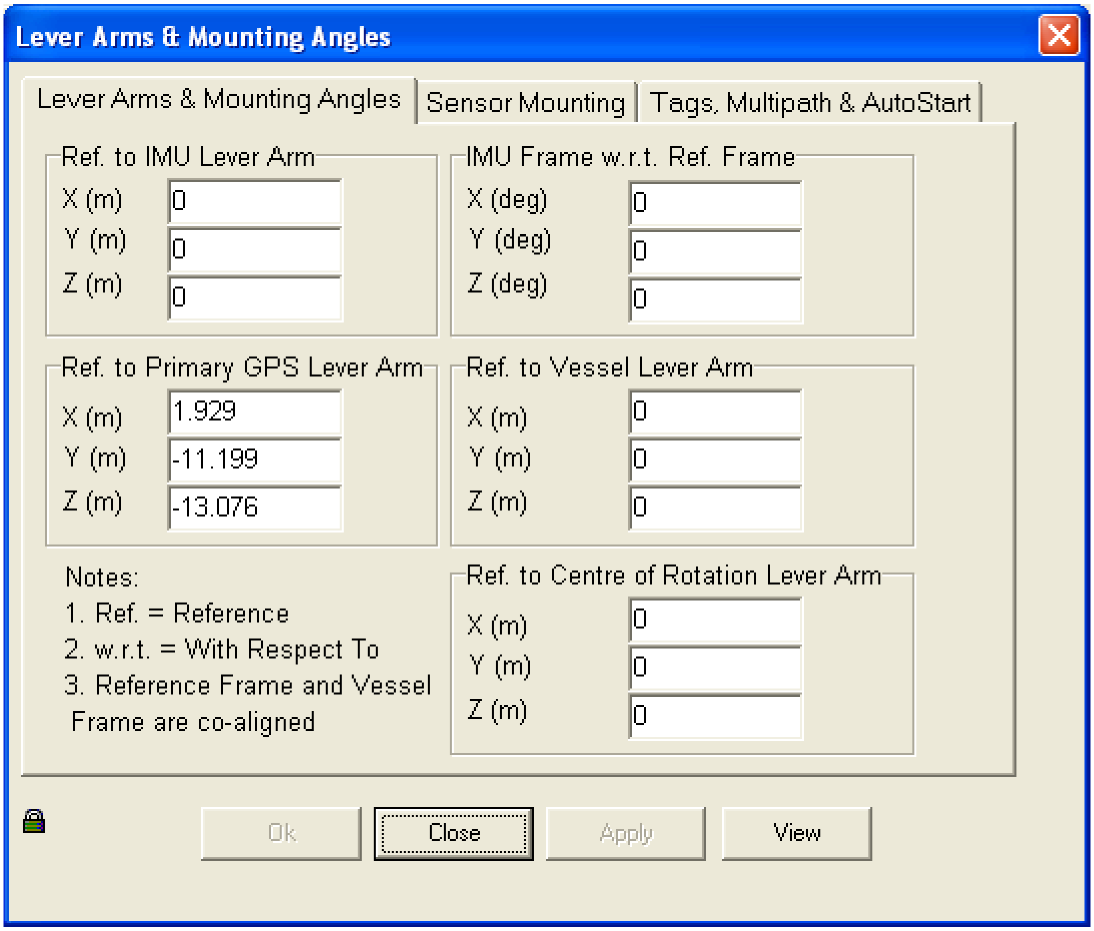
STRB POSMV

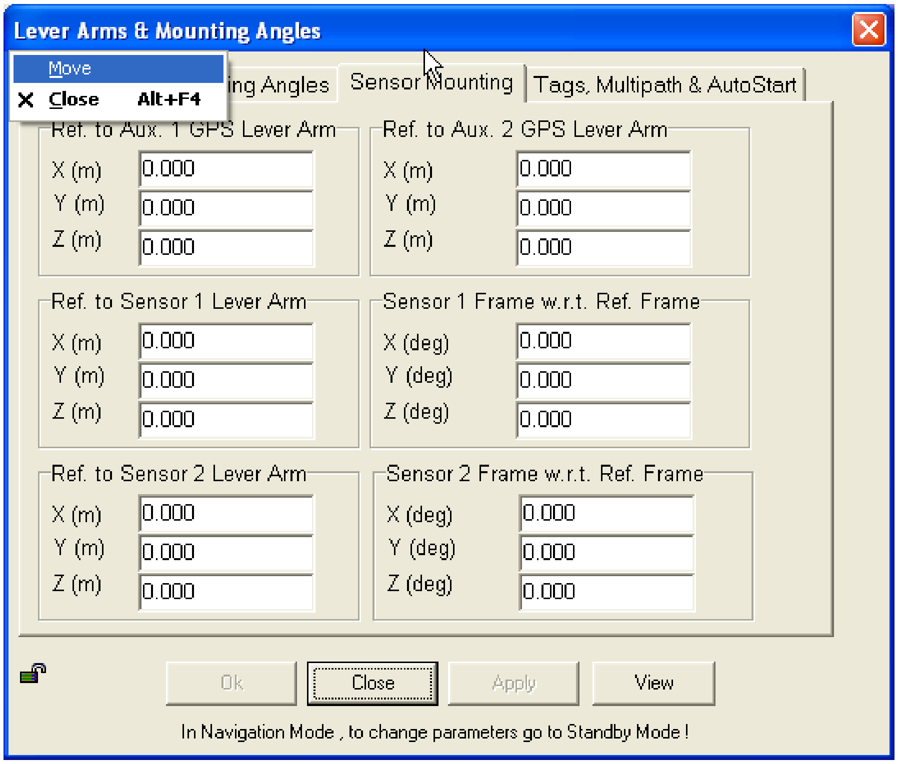

Statistics
POS Version
MV-320,VER4,S/N3189,HW3.3-7,SW05.03-Mar10/10,ICD04.02,OS425B14,IMU2,PGPS13,SGPS13,RTK-0,THV-0,DPW-0
GPS Receivers
Primary Receiver
BD950 SN:4808A98939, v.00232, channels:24
Secondary Receiver
BD950 SN:4642A73565, v.00232, channels:24
Statistics
Total Hours 215.7
Total Runs 21
Average Run (hours) 10.3
Longest Run (hours) 65.5
Current Run (hours) 24.8
Close


Installation Wizard
Vessel View
Show Sensor View
0
0

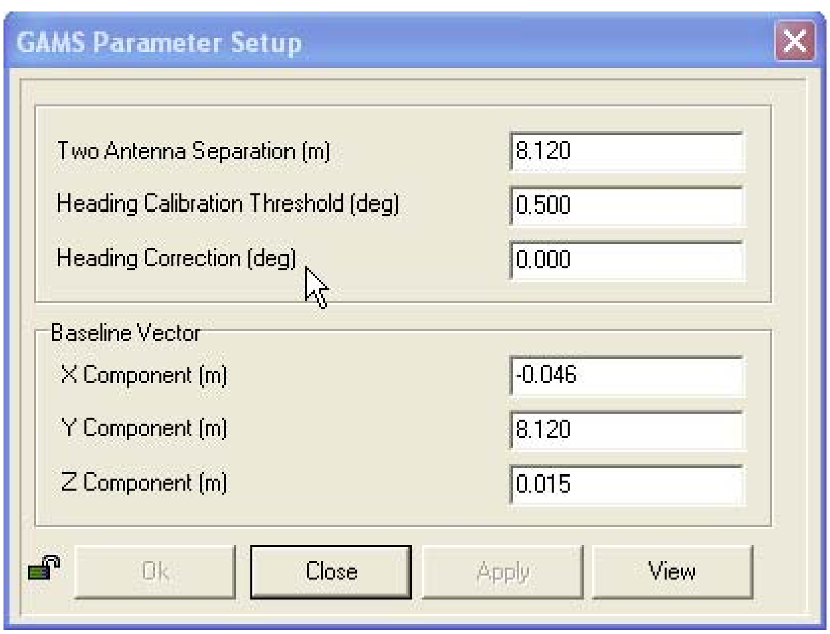
```
POSRT Data Extraction Utility [Jun 15 2011]
Copyright (c) 2008-2011 Applanix Corporation.  All rights reserved.
Date : 07/25/11    Time : 15:12:36
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
First POS file      : E:\Clients config, IP, & test results\Swath 250 Testing\Final
Report Files\Final_Data_IMUcorrect\For Bruce Frances\2011_152_S250_Stbd_GAMS.000
Last POS file       : E:\Clients config, IP, & test results\Swath 250 Testing\Final
Report Files\Final_Data_IMUcorrect\For Bruce Frances\2011_152_S250_Stbd_GAMS.003
Output path         : C:\Documents and Settings\bfrancis\My Documents\POSPac
MMS\Unnamed(2)\Mission 1\Extract
Output kernel       : Mission 1
Start time          : 0.000
End time            : 999999.000
VNAV output modulus : 1
--------------------------------------------------------------------------------
Opening file: E:\Clients config, IP, & test results\Swath 250 Testing\Final Report
Files\Final_Data_IMUcorrect\For Bruce Frances\2011_152_S250_Stbd_GAMS.000
307625.639 : Output time 1 is in UTC time
307625.639 : Output time 2 is in POS time
307625.639 : Output distances are in POS distance
307625.639 : IMU type: IMU2  Data rate = 200 Hz
307625.639 : Extracting Group 4 : Time-tag data
307625.649 : SNV status changed to 0  (Full Nav)
307626.069 : Primary GPS receiver type is GPS13.
307626.094 : Secondary GPS receiver type is GPS13.
307626.144 : Extracting Group 10: The General Status & FDIR data.
307626.144 : GenA( 2):  IIN quadrant resolved SET.
307626.144 : GenA( 3):  IIN fine align active SET.
307626.144 : GenA( 4):  IIN navigator initialized SET.
307626.144 : GenA( 5):  IIN navigator alignment active SET.
307626.144 : GenA( 7):  IIN full navigation solution SET.
307626.144 : GenA( 8):  IIN initial position valid SET.
307626.144 : GenA(16):  RAM config != NVM SET.
307626.144 : GenB( 0):  IIN user attitude performance SET.
307626.144 : GenB( 1):  IIN user heading performance SET.
307626.144 : GenB( 2):  IIN user position performance SET.
307626.144 : GenB( 3):  IIN user velocity performance SET.
307626.144 : GenB( 8):  GAMS installation parameters valid SET.
307626.144 : GenB( 9):  GAMS solution in use SET.
307626.144 : GenB(10):  GAMS solution OK SET.
307626.144 : GenB(16):  Primary GPS configuration file sent SET.
307626.144 : GenB(18):  Primary GPS in CA mode SET.
307626.144 : GenB(23):  Primary GPS observables in use SET.
307626.144 : GenB(24):  GAMS secondary GPS observables in use SET.
307626.144 : GenC( 6):  RTCM Type 1 or 9 in use SET.
307626.144 : GenC(13):  IIN in RTCM DGPS aided mode SET.
307626.144 : FDIR1(13): Ephemeris missing SET.
--------------------------------------------------------------------------------
307626.144 : The First Group 99: Versions & Statistics
   System Version:
     Product-Model: MV-320; Version: VER4; Serial Number: S/N3189;
     Hardware Version: HW3.3-7;
     Software Release Version-Date: SW05.03-Mar10/10;
     ICD release version: ICD04.02;
     Operating System Version: OS425B14;
     IMU Type: IMU2; Primary GPS Type: PGPS13; Secondary GPS Type: SGPS13;
     Option mnemonic-Expiry Time: DMI0;
     Option mnemonic-Expiry Time: GIM0;
     Option mnemonic-Expiry Time: RTK-0;
     Option mnemonic-Expiry Time: THV-0;
     Option mnemonic-Expiry Time: DPW-0;
   Primary GPS Version: BD950    SN:4808A98939, v.00232, channels:24;
   Secondary GPS Version: BD950  SN:4642A73565, v.00232, channels:24;
   Total Hours          :    789.9; Number of Runs:     66
   Average Length of Run:   12.0; Longest Run:   84.0; Current Run:   12.2;
--------------------------------------------------------------------------------
307626.144 : Diffcorr2 time1 gap: start 0.0, end 307626.1439
```

```
-------------------------------------------------------------------------------
307633.139 : Message 50: Transition to NAVIGATE mode.
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
307633.139 : Message 37: Base 1 setup
   Input data type expected: RTCM 1 or 9
   Datum Type: NAD83
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
307633.139 : Message 38: Base 2 setup
   Input data type expected: RTCM 1 or 9
   Datum Type: WGS84
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
307633.139 : Message 20: General parameters
   Time and distance tag types:         2  1
   Autostart selection:                  ENABLED
   Reference-IMU lever arm:             -0.008  -0.031  0.130
   Reference-primary GPS lever arm:     1.929  -11.199  -13.076
   Reference-auxiliary 1 GPS lever arm:  0.000  0.000  0.000
   Reference-auxiliary 2 GPS lever arm:  0.000  0.000  0.000
   Reference-IMU mounting angles:       0.000  0.000  0.000
   Reference-vehicle mounting angles:    0.000  0.000  0.000
   Multipath environment:                LOW
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
307633.139 : Message 24: User accuracy parameters
   User position accuracy:       2.00
   User velocity accuracy:       0.50
   User attitude accuracy:       0.05
   User heading accuracy:        0.05
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
307633.139 : Message 106: Heave ratios
   Heave Bandwidth (sec):  12.000
   Heave Damping Ratio:  0.707
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
307633.139 : Message 120: Heave and sensor 1&2 install parameters
   Reference-Sensor1 alignment angles (R,P,Y) in degrees:  0.000  0.000  0.000
   Reference-Sensor2 alignment angles (R,P,Y) in degrees:  0.000  0.000  0.000
   Reference-Sensor1 lever arm in meters:                  0.000  0.000  0.000
   Reference-Sensor2 lever arm in meters:                  0.000  0.000  0.000
   Reference-Centre of Rotation in meters:                 0.000  0.000  0.000
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
307633.139 : Message 121: Vessel Installation Parameters
   Reference-Vessel in meters:                             0.00  0.00  0.00
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
307633.139 : Message 32: PCS IP address
   IP Address (Network part 1): 129
   IP Address (Network part 2): 100
   IP Address (Host part 1):    1
   IP Address (Host part 2):    231
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
307633.139 : Message 56: General data
   Initial status:     COARSE_LEVEL
   Initial position:   30.339738973 -88.576114608 -17.526
   Initial distance:   0.00
   Initial attitude:   0.000 0.000 0.000
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
307633.139 : Message 21: GAMS install parameters
   A-B antenna separation:        8.122
   A-B baseline vector:           0.170 8.120 -0.003
   Heading error for calibration: 0.50
   A-B azimuth correction:        0.000
-------------------------------------------------------------------------------
```

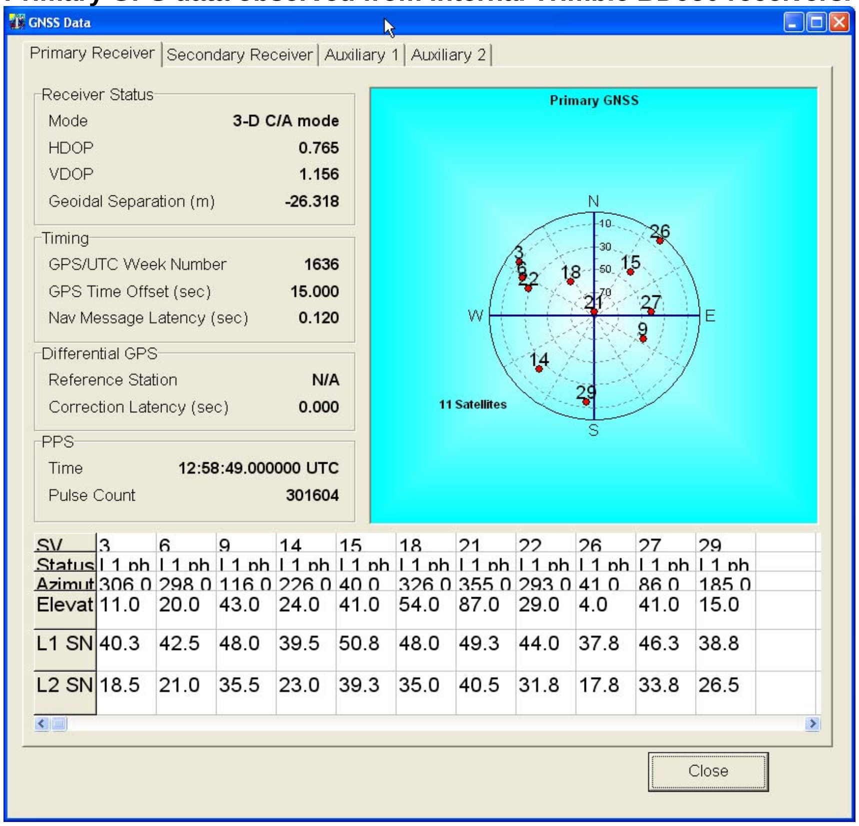

Lever Arms & Mounting Angles
Lever Arms & Mounting Angles
Sensor Mounting
Tags, Multipath & AutoStart
Ref. to IMU Lever Arm
X (m) 0
Y (m) 0
Z (m) 0
IMU Frame w.r.t. Ref. Frame
X (deg) 0
Y (deg) 0
Z (deg) 0
Ref. to Primary GPS Lever Arm
X (m) 1.929
Y (m) -11.199
Z (m) -13.076
Ref. to Vessel Lever Arm
X (m) 0
Y (m) 0
Z (m) 0
Notes:
1. Ref. = Reference
2. w.r.t. = With Respect To
3. Reference Frame and Vessel Frame are co-aligned
Ref. to Centre of Rotation Lever Arm
X (m) 0
Y (m) 0
Z (m) 0
Ok
Close
Apply
View



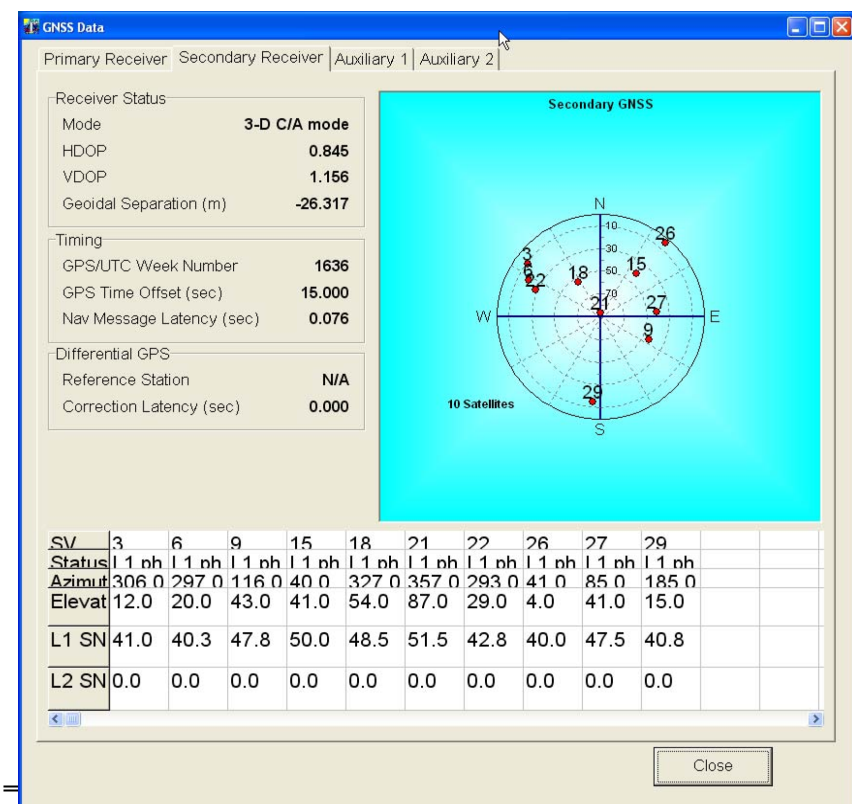
Observed GAMS values derived from the field calibration:
STRB GAMS Cal #1



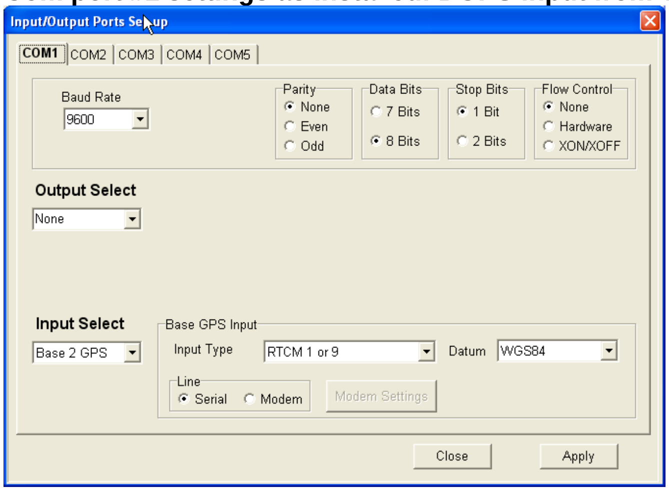
Primary GPS data observed from internal Trimble BD950 receivers.



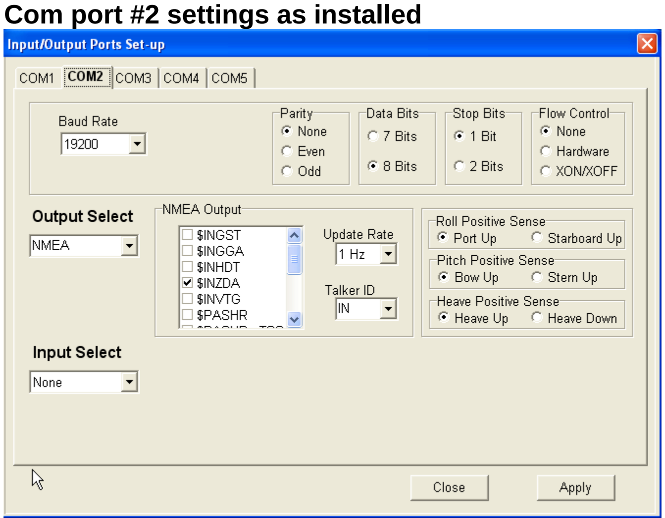
Secondary embedded GPS data:



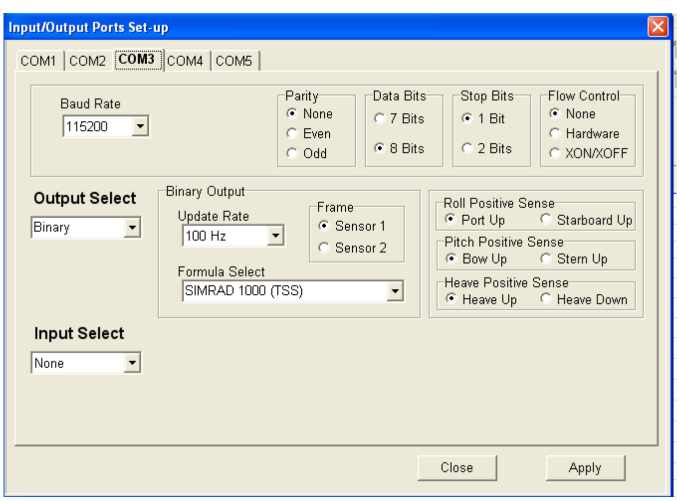
Com port #1 settings as installed: DGPS input from Trimble SPS Receiver.



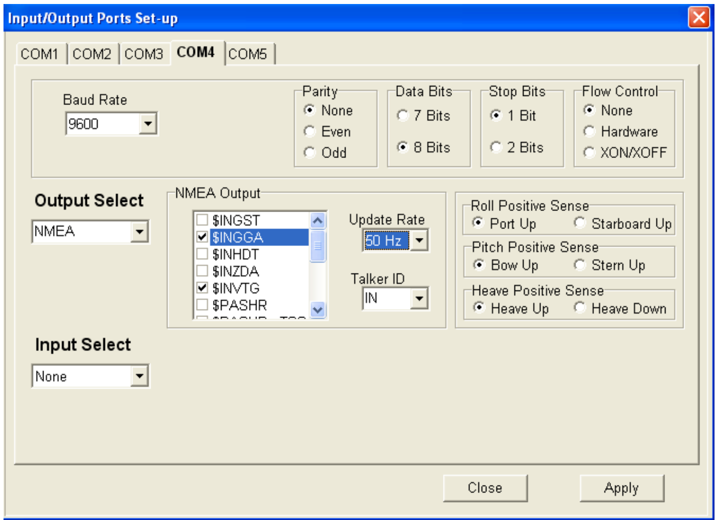
Com port #2 settings as installed



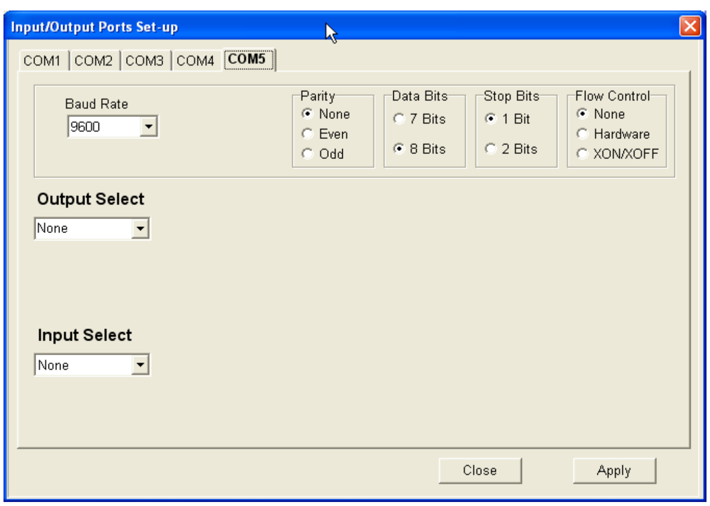
Com port #3 settings as installed:



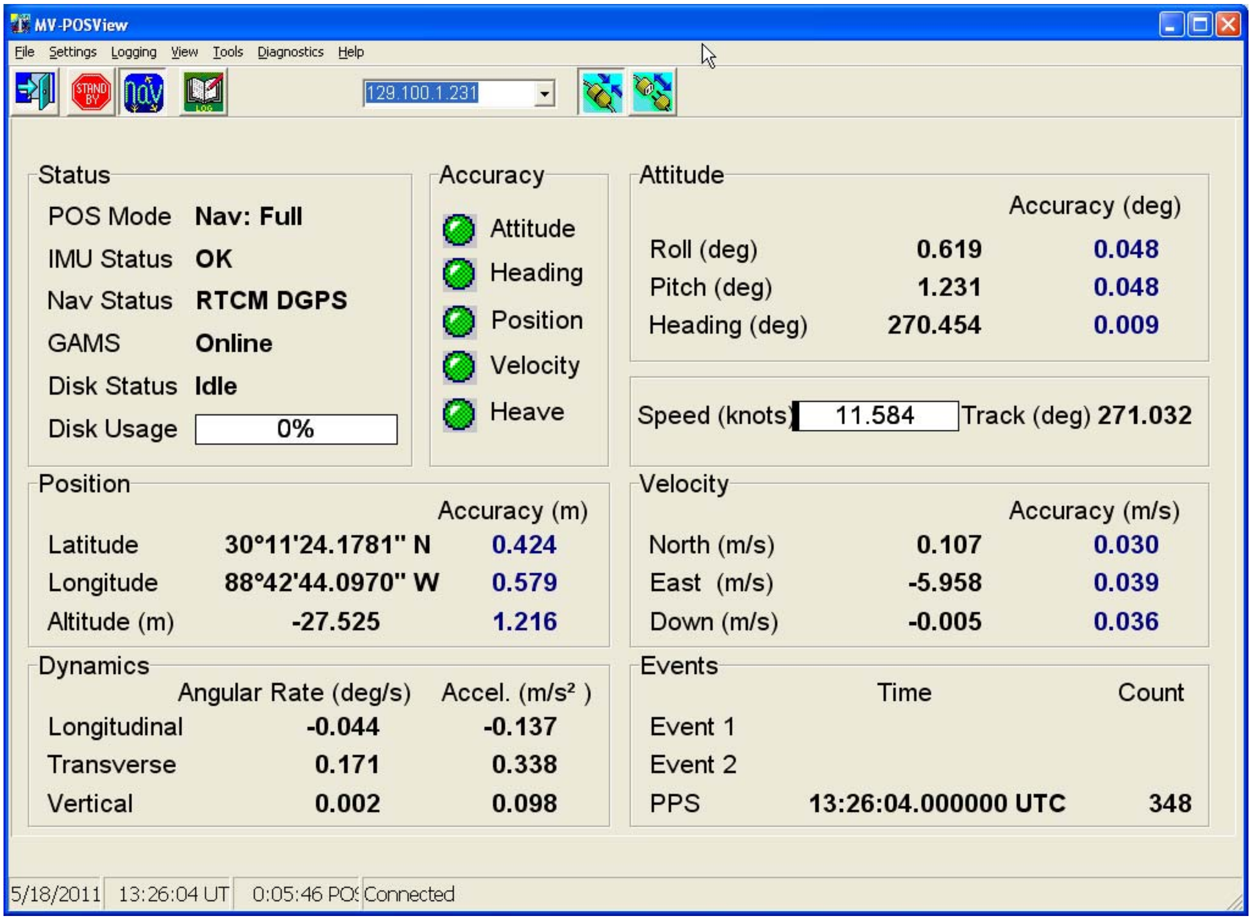
Com port #4 settings as installed:



Com port #5 settings as installed



STRB POSMV Final Navigation



STRB side antenna and IMU mounting:

STRB IMU Mount

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Certificate of Compliance

This document certifies that the system below meets the stated requirements.

Product	**MV V5**
Model	**320**
Sales Order #	**SO-010674**

Hardware Item	Part No	Serial No
POS	SAMVPCS02RM	5806
IMU TOP HAT	10004878	2423_423310

Requirement: **µPOS SA System Acceptance Test #PRO-WI-000094**

Result: **Passed**

Authorised signature: ______________

Date: June 26. 2013

85 Leek Crescent Richmond Hill, Ontario Canada L4B 3B3
Tel: (905) 709-4600 **Fax:** (905) 709-6027 **Web:** www.applanix.com

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A TRIMBLE COMPANY

Certificate of Compliance

This document certifies that the system below meets the stated requirements.

Product	**MV V5**
Model	**320**
Sales Order #	**SO-010674**

Hardware Item	Part No	Serial No
POS	**SAMVPCS02RM**	**5807**
IMU TOP HAT	**10004878**	**2424_424204**

Requirement: **μPOS SA System Acceptance Test #PRO-WI-000094**

Result: **Passed**

Authorised signature: 3

Date: June 26. 2013

85 Leek Crescent Richmond Hill, Ontario Canada L4B 3B3
Tel: (905) 709-4600 **Fax:** (905) 709-6027 **Web:** www.applanix.com

NOAA POS/MV Calibration Report

Fill out all fields! See previous years as an example.

Yellow areas require screen grabs!

Ship: Ferdinand R. Hassler **Vessel:** 2702

Date: 3/3/2016 **Dn:**

Personnel: Berube, Schoolcraft, Morgan

PCS Serial # **IMU Serial #**

IP Address: 129.100.1.231

POS controller Version (Use Menu Help > About)

POS Version (Use Menu View > Statistics)

GPS Receivers

Primary Receiver Serial #:

Secondary Receiver Serial #:

Calibration area

Location: York River

Approximate Position:

Lat	37	14	22.5
Lon	76	29	58.9

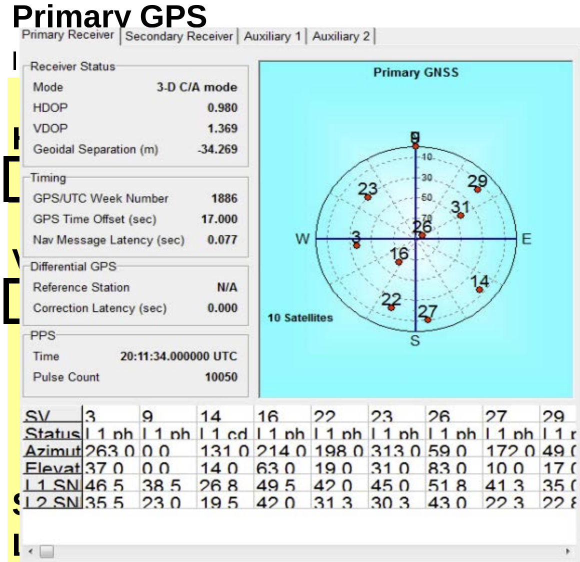
DGPS Beacon Station: RTK AHB **DGPS Receiver Serial#:**

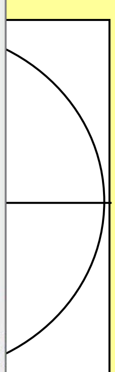
Frequency:

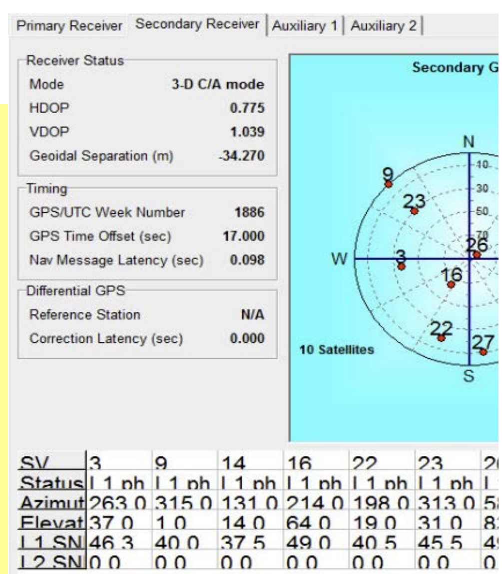
Satellite Constellation

(Use View> GPS Data)

Primary GPS



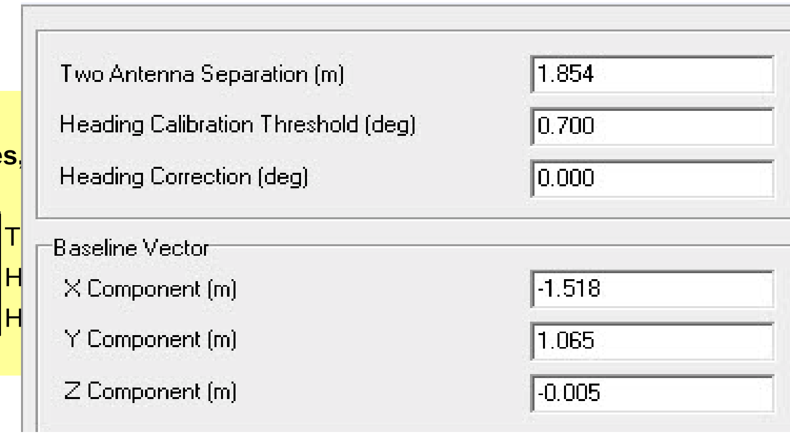




PDOP 1.8 (Use View> GAMS Solution)

POS/MV Configuration
Settings

Gams Parameter Setup



User Entries,

T ... ment
H ... ent
H ... ment

Configuration Notes:

POS/MV Calibration

Calibration Procedure:

(Refer to POS MV V4 Installation and Operation Guide, 4-25)

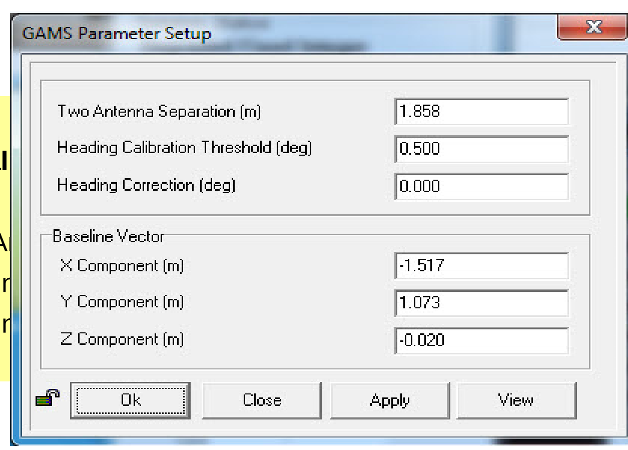
Start time: 2009

End time: 2011

Heading accuracy achieved for calibration: 0.230 before 0.028 after

Calibration Results:

Gams Parameter Setup



POS/MV Post-Cal

Two A ... Component
Headin ... Component
Headin ... Component

GAMS Status Online

Save Settings

Calibration Notes:

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

File Name: ____________________

General Notes:

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

The right-hand orthogonal system defines the following:

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

The POS/MV uses a Tate-Bryant Rotation Sequence

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

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

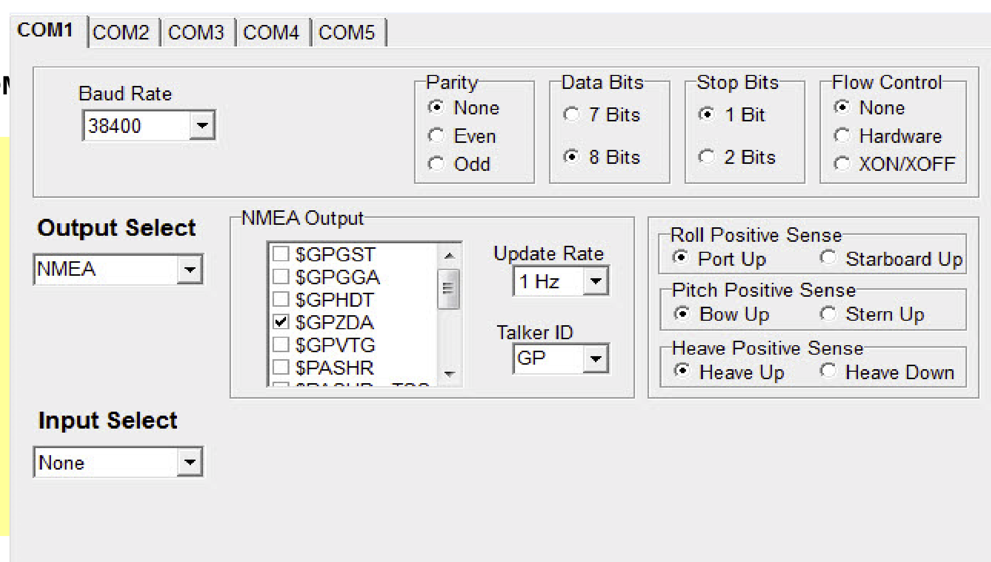
b) Pitch rotation - apply a right-hand screw rotation θy about the once-rotated y-axis to align one frame with the other.

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

SETTINGS

Input/Output Ports

COI

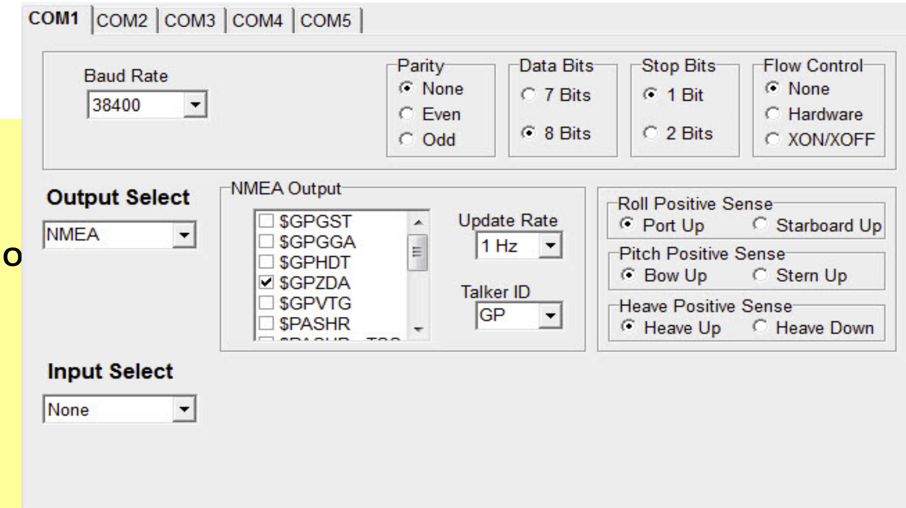


e

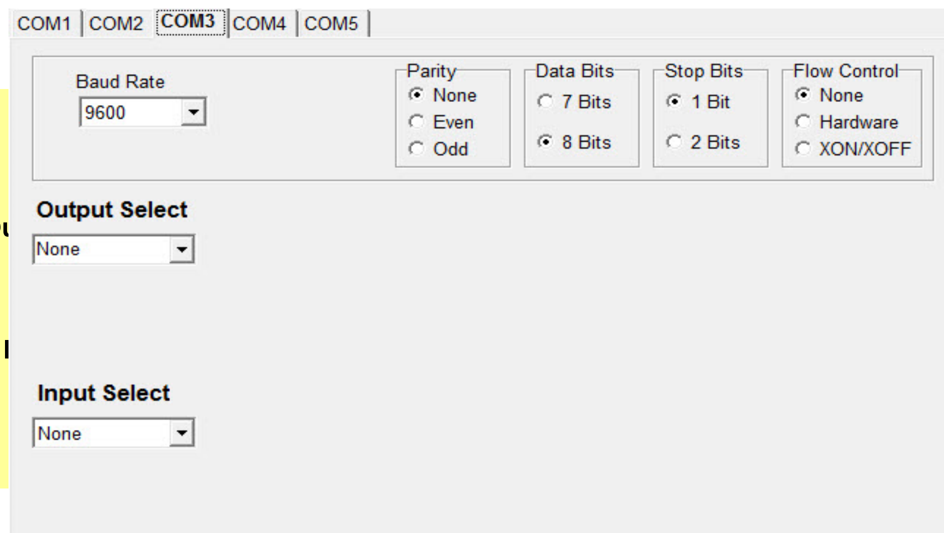
NMEA Output (selected strings shown here)

	$INVTG		$PASHR TB	x	$INZDA	set as GP
	$INGST		$PASHR TSS		$INGGK	
	$INGGA		$PRDID TB		$UTC	
	$INHDT		$PRDID TSS			

COM2



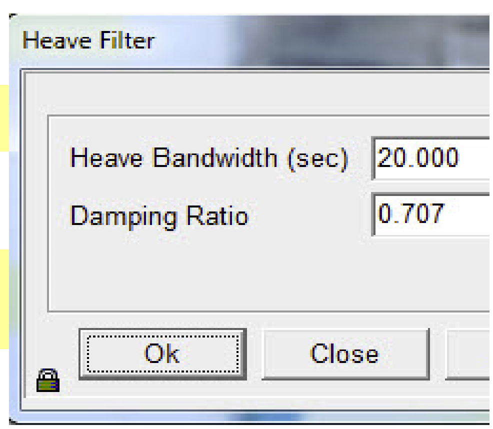
COM3



SETTINGS Continued

Heave Filter (Use Settings > Heave)

	Heave Bandwidth
	Damping Ratio



Events (Use Settings > Events)

1

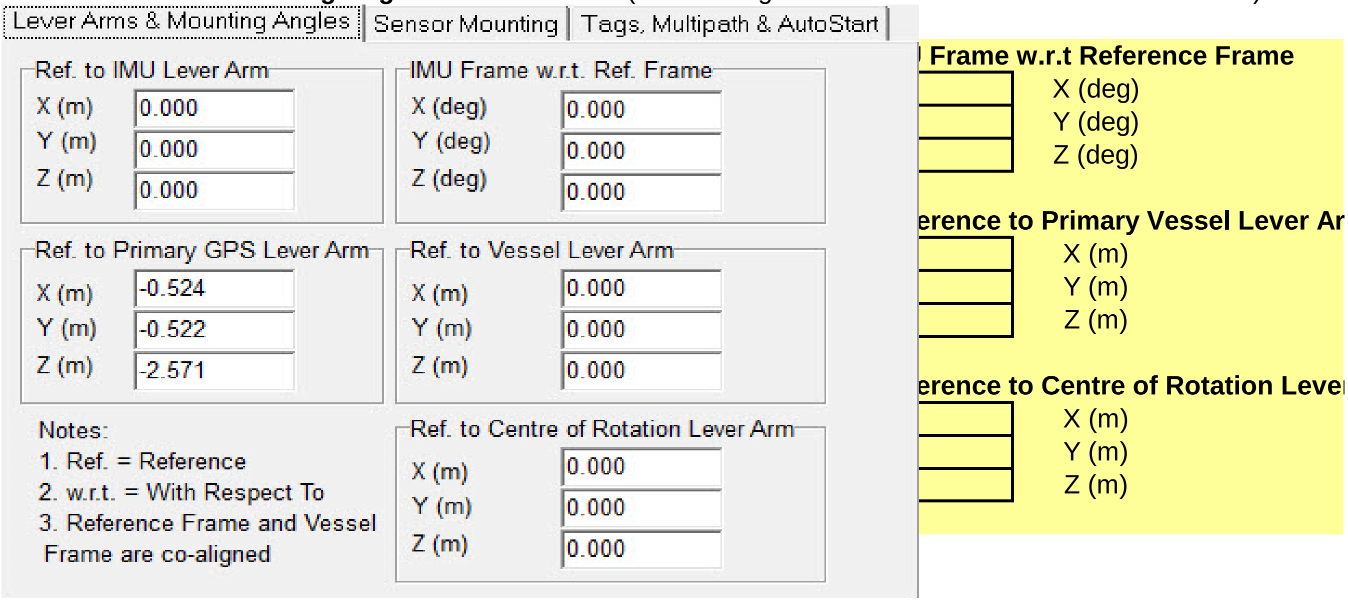
Positive, Negative Edge Trigger

2

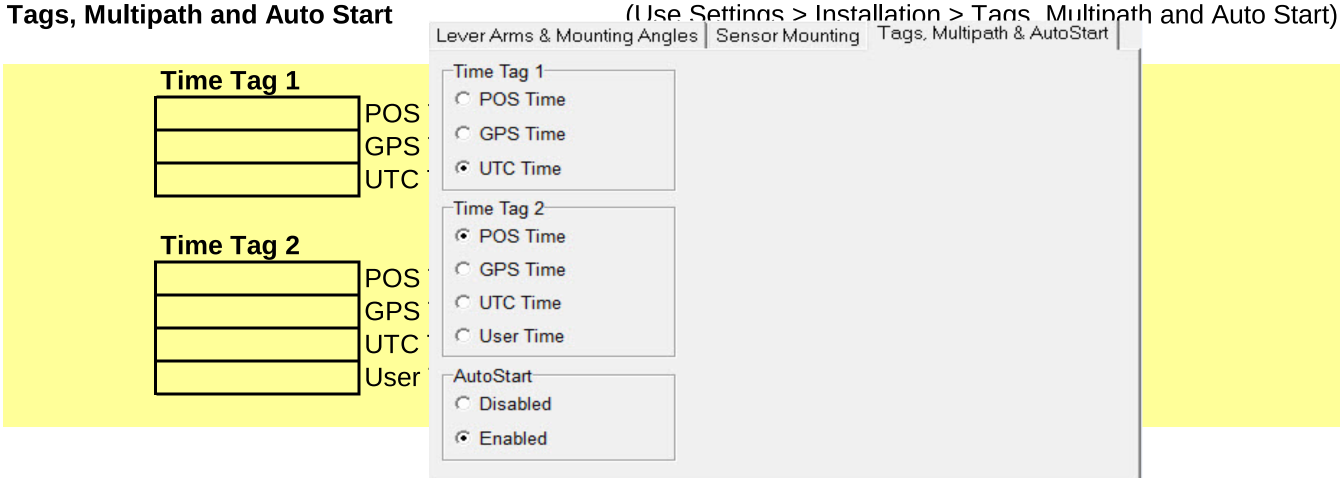
INSTALLATION

(Use Settings > Installation)

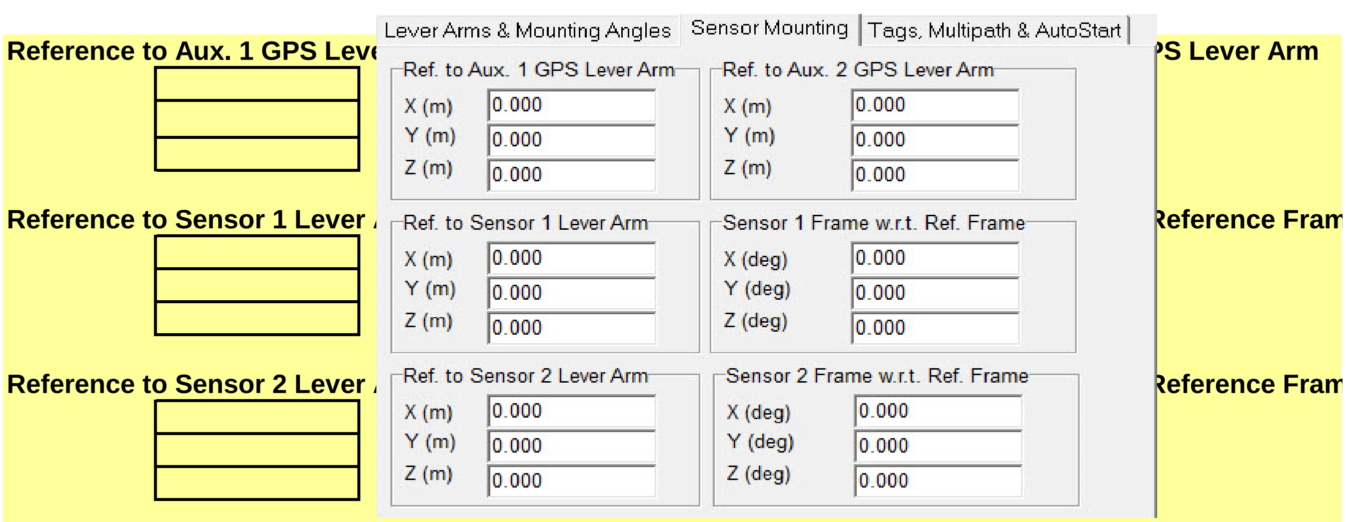
Lever Arms and Mounting Angles (Use Settings > Installation > Lever Arms and Offsets)



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



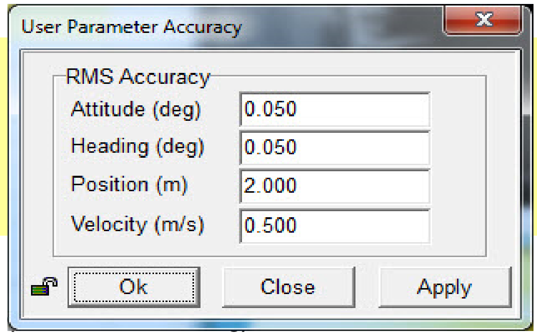
Sensor Mounting (Use Settings > Installation > Sensor Mounting)



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

RMS Accuracy

	Attitude (deg)
	Heading (deg)
	Position (m)
	Velocity (m/s)



Frame Control

	User Frame
	IMU Frame

Primary GPS Measurement ________

Auxiliary GPS Measurement ________

	Use GAMS enabled

GPS Receiver Configuration

(Use Settings> Installation> GPS Receiver Configuration)

Primary GPS Receiver

Baud Rate	Parity	Data	Stop

Auto Configuration

	Enabled
	Disabled

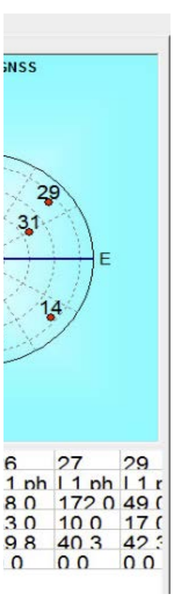
Secondary GPS Receiver

Baud Rate	Parity	Data	Stop

Auto Configuration

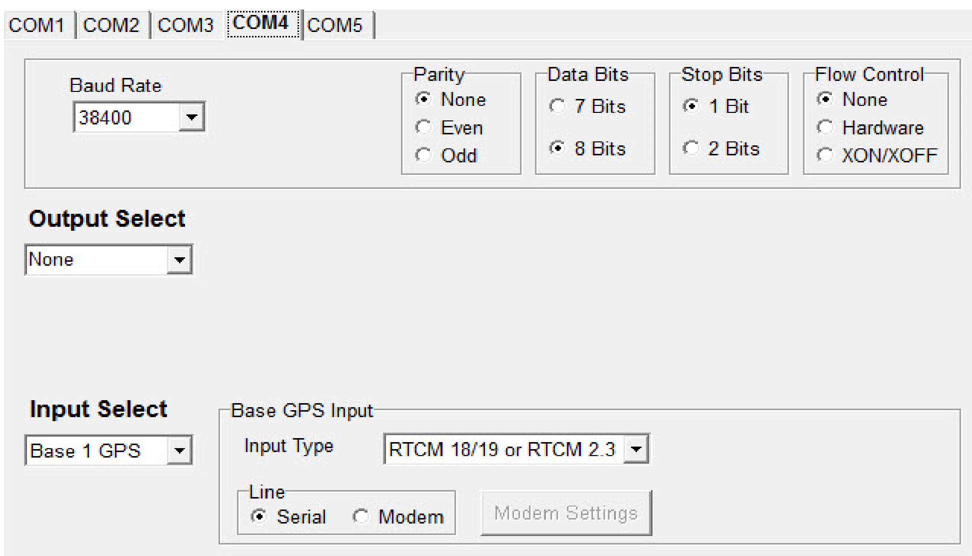
	Enabled
	Disabled

v12_0_1



: (m)
(m)
(m)

: (m)
(m)
(m)


COM1
COM2
COM3
COM4
COM5
Baud Rate
38400
Parity
None
Even
Odd
Data Bits
7 Bits
8 Bits
Stop Bits
1 Bit
2 Bits
Flow Control
None
Hardware
XON/XOFF
Output Select
None
Input Select
Base 1 GPS
Base GPS Input
Input Type
RTCM 18/19 or RTCM 2.3
Line
Serial
Modem
Modem Settings


Apply

rm

r Arm

ne

ne

NOAA POS/MV Calibration Report

Fill out all fields! See previous years as an example.

Yellow areas require screen grabs!

Ship: Ferdinand R. Hassler

Vessel: Ferdinand Hassler

Date: 2/11/2016

Dn: 42

Personnel: Berube, Wilson

PCS Serial #

IMU Serial #

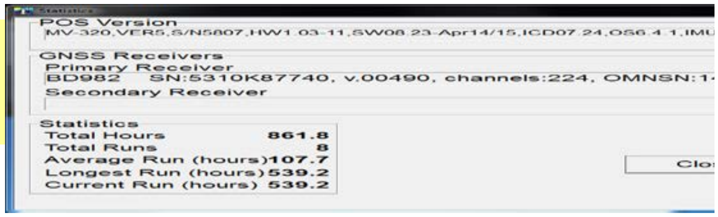
IP Address: 129.100.1.232

POS controller Version (Use Menu Help > About) 8.15

POS Version (Use Menu View > Statistics)
GPS Receivers

Primary Receiver Serial #:

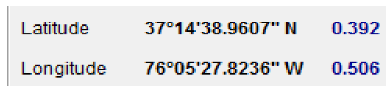
Secondary Receiver Serial #:



Calibration area

Location: Chesapeake Bay, Cape Charles

Approximate Position: **Lat** **Lon**



DGPS Beacon Station: Driver, VA

DGPS Receiver Serial#:

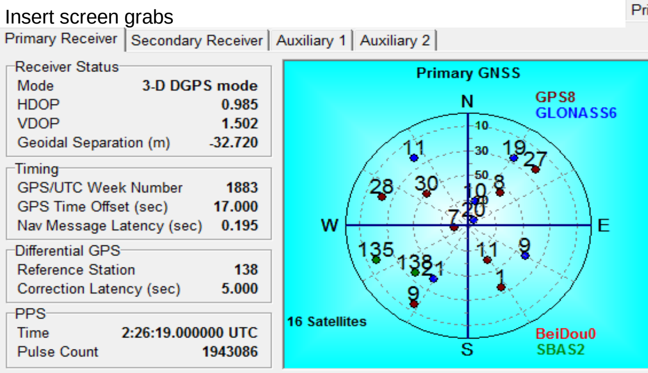
Frequency: 289 kHz

Satellite Constellation

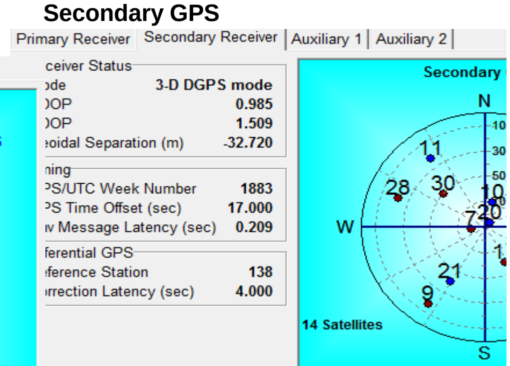
(Use View> GPS Data)

Primary GPS

Insert screen grabs



Secondary GPS



L1 SNR > 30 35 40

L1 SNR > 30 35 40

PDOP 1.788 (Use View> GAMS Solution)

POS/MV Configuration

Settings

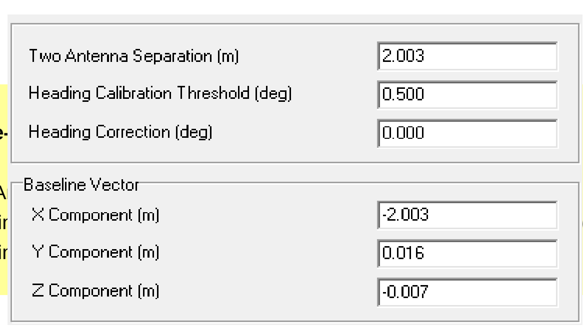
Gams Parameter Setup

User Entries, Pre-

Two A (m)

Headir (m)

Headir (m)



Configuration Notes:

POS/MV Calibration

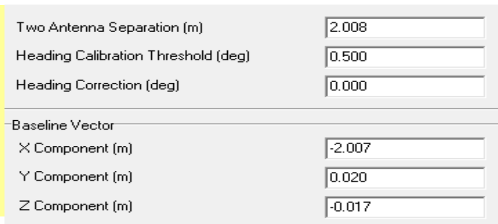
Calibration Procedure:

(Refer to POS MV V4 Installation and Operation Guide, 4-25)

Start time: aprox 0220
End time: 236
Heading accuracy achieved for calibration: 0.023

Calibration Results:

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



Baseline Vector
X Component (m)
YComponent (m)
Z Component (m)

GAMS Status Online x
Save Settings x

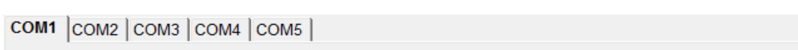
Calibration Notes:

Save POS Settings on PC (Use File > Store POS Settings on PC)
File Name: 2012_042_Initial_GAMS

General Notes:

The POS/MV uses a Right-Hand Orthogonal Reference System
The right-hand orthogonal system defines the following:
• The x-axis is in the fore-aft direction in the appropriate reference frame.
• The y-axis is perpendicular to the x-axis and points towards the right (starboard) side in the appropriate reference frame.
• The z-axis points downwards in the appropriate reference frame.

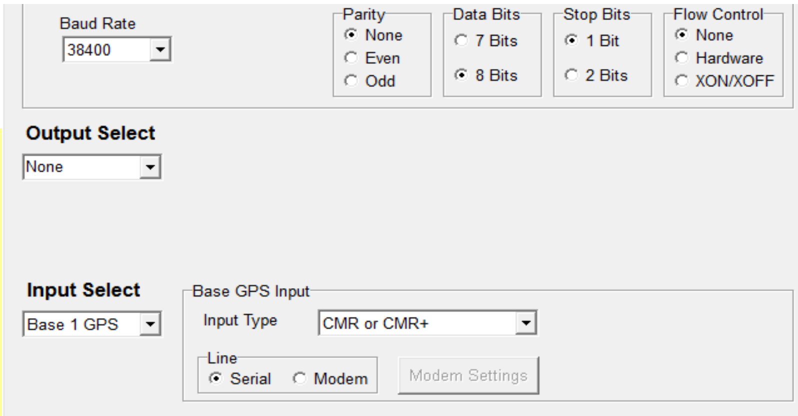
The POS/MV uses a Tate-Bryant Rotation Sequence
Apply the rotation in the following order to bring the two frames of reference into complete alignment:
a) Heading rotation - apply a right-hand screw rotation θz about the z-axis to align one frame with the other.
b) Pitch rotation - apply a right-hand screw rotation θy about the once-rotated y-axis to align one frame with the other.
c) Roll rotation - apply a right-hand screw rotation θx about the twice-rotated x-axis to align one frame with the other.



SETTINGS

Input/Output Ports

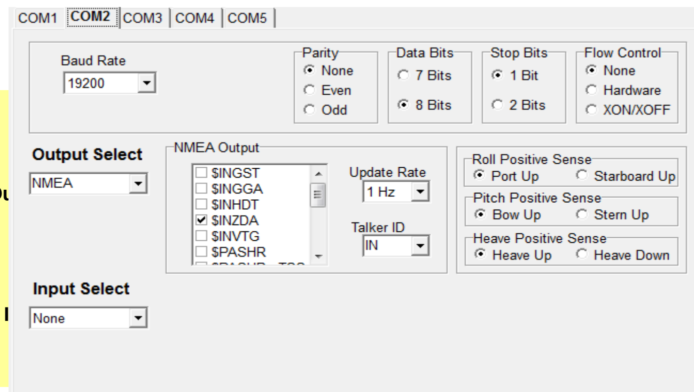
COM1



NMEA Output (selected strings shown here) com2

	$INVTG		$PASHR TB	x	$INZDA
	$INGST		$PASHR TSS		$INGGK
	$INGGA		$PRDID TB		$UTC
	$INHDT		$PRDID TSS	x	$PPS

COM2



Ou

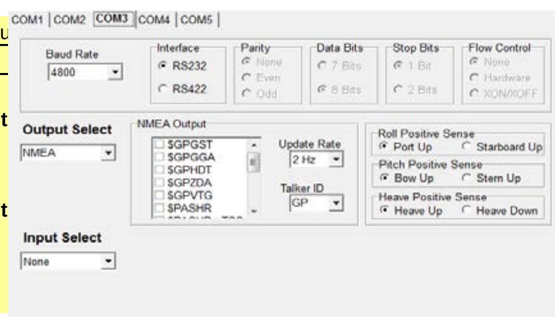
I

COM3

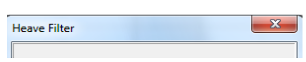
Bau

Output

Input

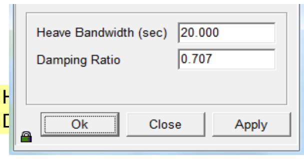


$GPRMC



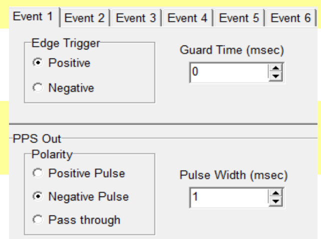
SETTINGS Continued

Heave Filter (Use Settings > Heave)



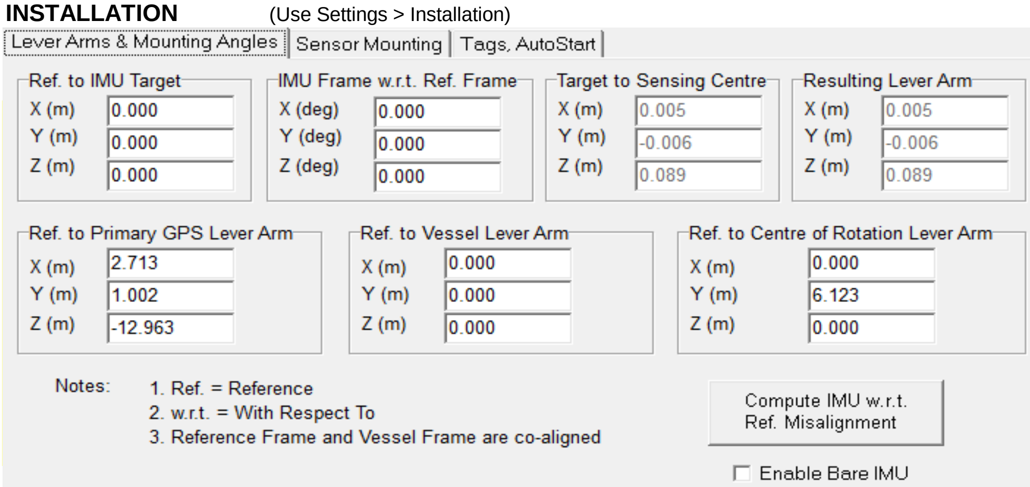
Events (Use Settings > Events)

1
Positive, Negative Edge Trigger
2



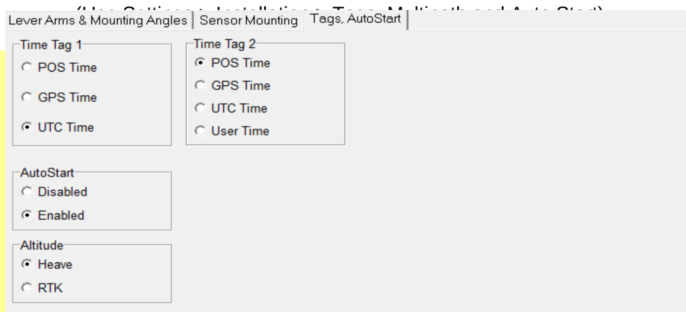
INSTALLATION

(Use Settings > Installation)



m

Tags, Multipath and Auto Start



Time Tag 1

POS Time
GPS Time
UTC Time

Time Tag 2

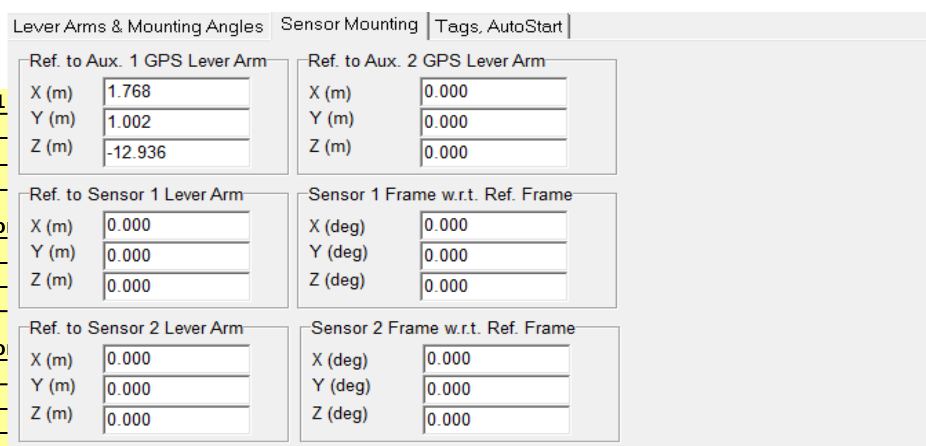
POS Time
GPS Time
UTC Time
User Time

Sensor Mounting

Reference to Aux. 1

Reference to Senso

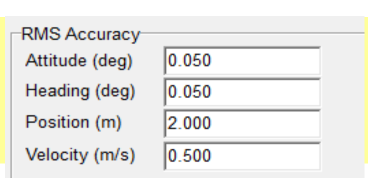
Reference to Senso



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

RMS Accuracy

Attitude (deg)
Heading (deg)
Position (m)
Velocity (m/s)



Frame Control (Use Tools > Config) couldn't open menu

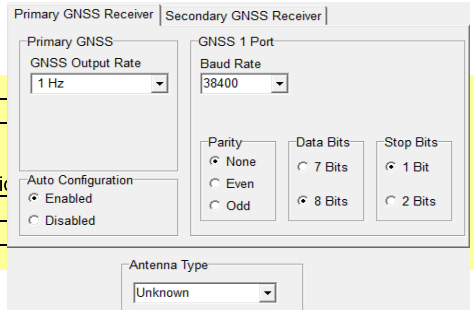
	User Frame	Primary GPS Measurement	
	IMU Frame	Auxiliary GPS Measurement	

Use GAMS enabled

GPS Receiver Configuration

(Use Settings> Installation> GPS Receiver Configuration)

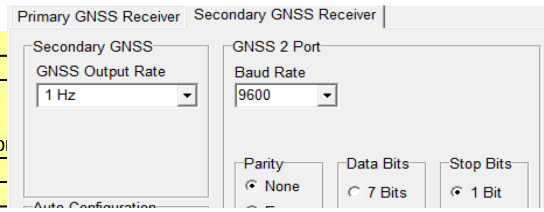
Primary GPS Receiver



Baud Rate

Auto Configuratio

Secondary GPS Receiver



Baud Rate

Auto Configuratio

NOAA POS/MV Calibration Report

Fill out all fields! See previous years as an example.

Yellow areas require screen grabs!

Ship: Ferdinand R. Hassler **Vessel:** Ferdinand Hassler

Date: 2/11/2016 **Dn:** 42

Personnel: Berube, Wilson

PCS Serial # **IMU Serial #**

IP Address: 129.100.1.231

POS controller Version (Use Menu Help > About) 8.15

POS Version (Use Menu View > Statistics)
GPS Receivers
Primary Receiver Serial #:
Secondary Receiver Serial #:

POS Version
MV-320,VER5,S/N5807,HW1.03-11,SW08.23-Apr14/15,ICD07.24,OS6.4.1,IMU36,PGPS17,SGPS17,R

GNSS Receivers
Primary Receiver
BD982 SN:5310K87740, v.00490, channels:224, OMNSN:1487740
Secondary Receiver

Calibration area

Location: Chesapeake Bay, offshore Cape Charles

Approximate Position: **Lat** **Lon**

Latitude	37°14'37.2694" N	0.396
Longitude	76°05'27.1951" W	0.507

DGPS Beacon Station: Driver, VA **DGPS Receiver Serial#:**

Frequency: 29 kHz

Satellite Constellation

(Use View> GPS Data)

Primary GPS

Insert screen grabs

HD VD Sa L1 SNR > 30 35 40

Receiver Status

Mode	3-D DGPS mode
HDOP	0.985
VDOP	1.510
Geoidal Separation (m)	-32.720

Timing

GPS/UTC Week Number	1883
GPS Time Offset (sec)	17.000
Nav Message Latency (sec)	0.208

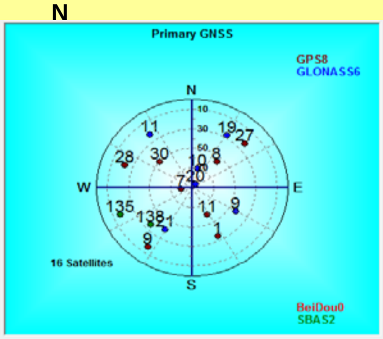
Differential GPS

Reference Station	138
Correction Latency (sec)	7.000

PPS

Time	2:25:46.000000 UTC
Pulse Count	1943821

N



Secondary GPS

Note any differences from Primary GPS Receiver

OP OP telites L1 SNR >

Receiver Status

Mode	3-D DGPS mod
HDOP	0.9
VDOP	1.5
Geoidal Separation (m)	-32.7

Timing

GPS/UTC Week Number	18
GPS Time Offset (sec)	17.0
Nav Message Latency (sec)	0.2

Differential GPS

Reference Station	1
Correction Latency (sec)	4.0

PDOP 1.794 (Use View> GAMS Solution)

POS/MV Configuration
Settings

Gams Parameter Setup

GAMS Parameter Setup

Two Antenna Separation (m)	2.006
Heading Calibration Threshold (deg)	0.500
Heading Correction (deg)	0.000

Baseline Vector

X Component (m)	-2.006
Y Component (m)	-0.029
Z Component (m)	-0.024

User Entries, Pre-C

Two Ant
Heading
Heading

nponent (m)
ponent (m)
nponent (m)

Configuration Notes:

POS/MV Calibration

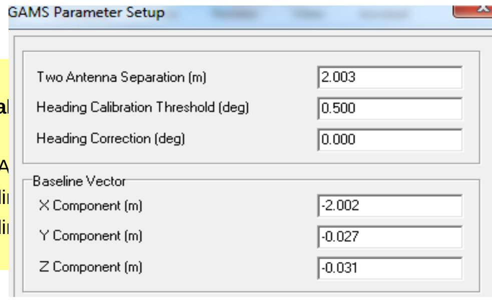
Calibration Procedure:

(Refer to POS MV V4 Installation and Operation Guide, 4-25)

Start time: Approx 0220
End time: 237
Heading accuracy achieved for calibration: 0.023

Calibration Results:

Gams Parameter Setup



POS/MV Post-Cal

	Two A	:omponent (m)
	Headi	omponent (m)
	Headi	omponent (m)

GAMS Status Online x
Save Settings x

Calibration Notes:

Save POS Settings on PC (Use File > Store POS Settings on PC)
File Name: 2016_042_Initial_GAMS

General Notes:

The POS/MV uses a Right-Hand Orthogonal Reference System
The right-hand orthogonal system defines the following:
- The x-axis is in the fore-aft direction in the appropriate reference frame.
- The y-axis is perpendicular to the x-axis and points towards the right (starboard) side in the appropriate reference frame.
- The z-axis points downwards in the appropriate reference frame.

The POS/MV uses a Tate-Bryant Rotation Sequence
Apply the rotation in the following order to bring the two frames of reference into complete alignment:
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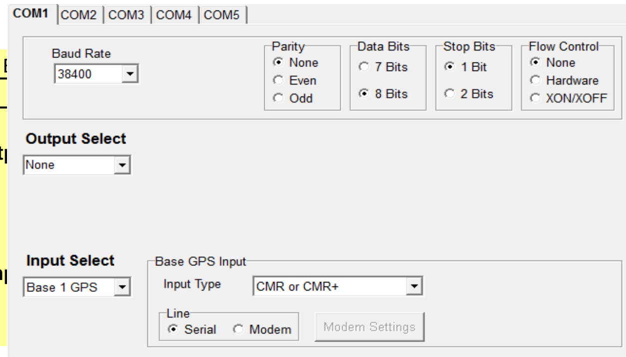
b) Pitch rotation - apply a right-hand screw rotation θy about the once-rotated y-axis to align one frame with the other.
c) Roll rotation - apply a right-hand screw rotation θx about the twice-rotated x-axis to align one frame with the other.

SETTINGS

Input/Output Ports (Use Settings > Input/Output Ports)

COM1

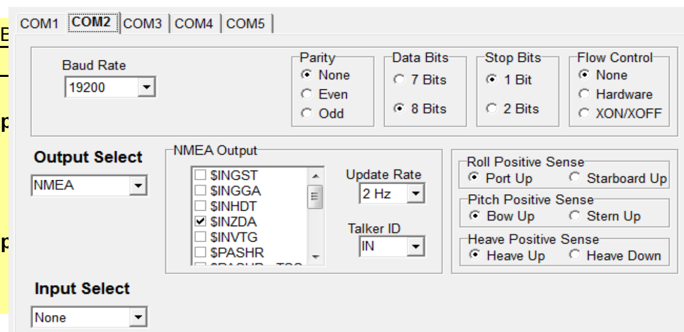


NMEA Output (selected strings shown here)

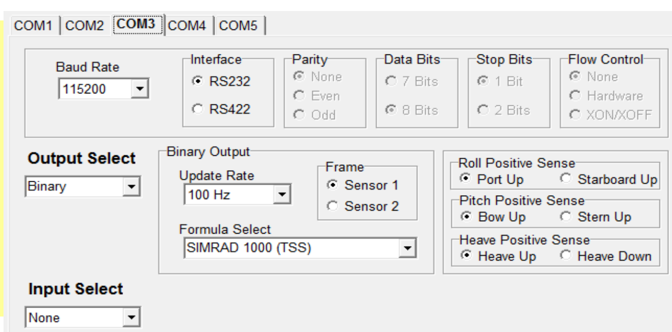
NMEA Output applied to

	$INVTG		$PASHR TB	x	$INZDA
	$INGST		$PASHR TSS		$INGGK
	$INGGA		$PRDID TB		$UTC
	$INHDT		$PRDID TSS	x	INPPS

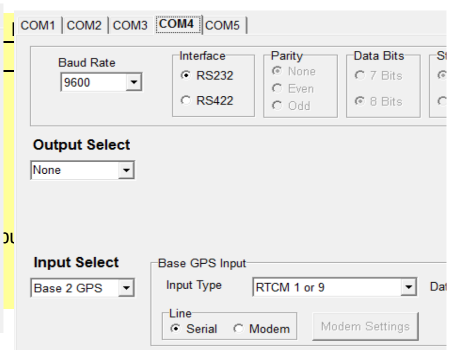
COM2



COM3



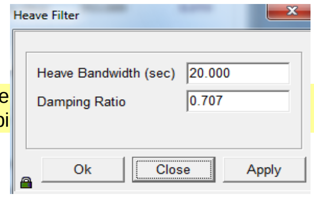
COM4



SETTINGS Continued

Heave Filter (Use Settings > Heave)

20	Heave
0.707	Dampi

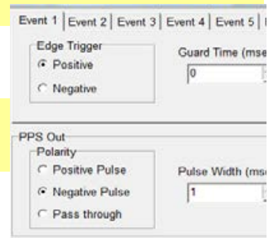


Events (Use Settings > Events)

1

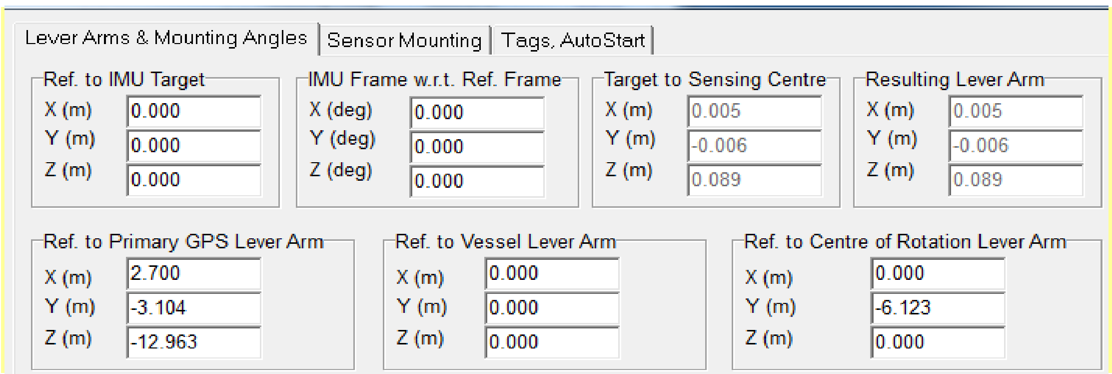
Positive, Negative Edge Trigger

2

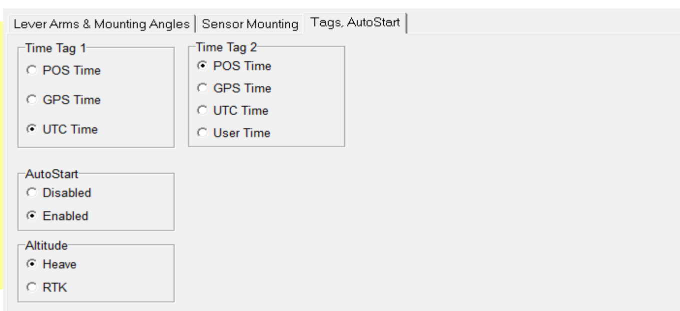


INSTALLATION (Use Settings > Installation)

Lever Arms and Mounting Angles (Use Settings > Installation > Lever Arms and Offsets)



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



ith

Low
Medium
High

art

Disabled
Enabled

Sensor Mounting (Use Settings > Installation > Sensor Mounting)

Reference to Aux. 1 GPS Lever Arm

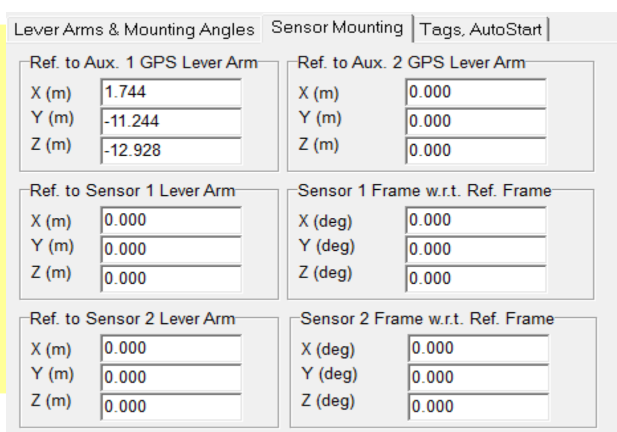
X (m)
Y (m)
Z (m)

Reference to Sensor 1 Lever Arm

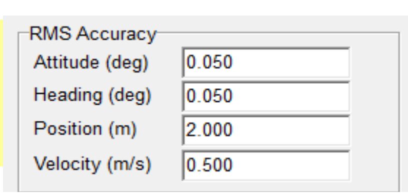
X (m)
Y (m)
Z (m)

Reference to Sensor 2 Lever Arm

X (m)
Y (m)
Z (m)



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



Frame Control (Use Tools > Config) Couldn't open menu

	User Frame	Primary GPS Measurement	
	IMU Frame	Auxiliary GPS Measurement	

	Use GAMS enabled

GPS Receiver Configuration

(Use Settings> Installation> GPS Receiver Configuration)

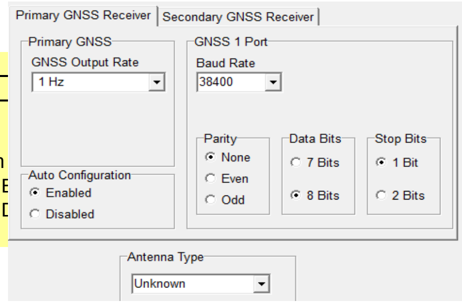
Primary GPS Receiver

Baud Rate

Auto Configuration

E

D



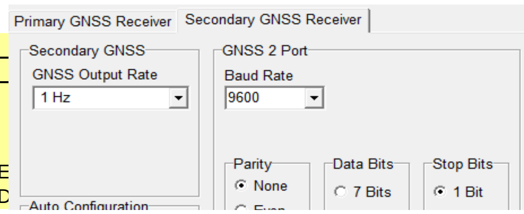
Secondary GPS Receiver

Baud Rate

Auto Configuration

E

D



Appendix IV

Sound Speed Sensor Reports

Certificate of Calibration

Customer:	NOAA - Marine Operations Center Atlantic
Asset Serial Number:	008609
Asset Product Type:	Micro CTD, Titanium, MVP, with Extended Temp & Cond Range
Calibration Type:	Conductivity
Calibration Range:	0 to 79 mS/cm
Calibration RMS Error:	.0022
Calibration ID:	008609 006895 500349 140116 135141
Installed On:	

Coefficient A:	-9.800008E-3	Coefficient H:	6.757492E-14
Coefficient B:	-3.740293E-7	Coefficient I:	0.000000E+0
Coefficient C:	5.527026E-9	Coefficient J:	0.000000E+0
Coefficient D:	-2.108338E-11	Coefficient K:	0.000000E+0
Coefficient E:	3.141028E-5	Coefficient L:	0.000000E+0
Coefficient F:	1.198812E-9	Coefficient M:	0.000000E+0
Coefficient G:	-1.771483E-11	Coefficient N:	0.000000E+0

Calibration Date (dd/mm/yyyy): 14/1/2016

Certified By:

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

AML Oceanographic
2071 Malaview Avenue, Sidney B.C. V8L 5X6 CANADA
T: +1-250-656-0771 F: +1-250-655-3655 Email: service@AMLoceanographic.com

Certificate of Calibration

Customer:	NOAA - Marine Operations Center Atlantic
Asset Serial Number:	008609
Asset Product Type:	Micro CTD, Titanium, MVP, with Extended Temp & Cond Range
Calibration Type:	Pressure
Calibration Range:	1000 dBar
Calibration RMS Error:	.0516
Calibration ID:	008609 005155 999999 150116 082413
Installed On:	

Coefficient A:	-1.233491E+2	Coefficient H:	0.000000E+0
Coefficient B:	0.000000E+0	Coefficient I:	2.765371E-9
Coefficient C:	0.000000E+0	Coefficient J:	0.000000E+0
Coefficient D:	0.000000E+0	Coefficient K:	0.000000E+0
Coefficient E:	1.898612E-2	Coefficient L:	0.000000E+0
Coefficient F:	0.000000E+0	Coefficient M:	-3.556292E-14
Coefficient G:	0.000000E+0	Coefficient N:	0.000000E+0

Calibration Date (dd/mm/yyyy): 15/1/2016

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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Certificate of Calibration

Customer:	NOAA - Marine Operations Center Atlantic
Asset Serial Number:	008609
Asset Product Type:	Micro CTD, Titanium, MVP, with Extended Temp & Cond Range
Calibration Type:	Temperature
Calibration Range:	-2 to +45 Deg C
Calibration RMS Error:	.001
Calibration ID:	008609 005155 400672 140116 135141
Installed On:	

Coefficient A:	-1.683849E+1	Coefficient H:	0.000000E+0
Coefficient B:	1.614658E-3	Coefficient I:	0.000000E+0
Coefficient C:	-3.265849E-8	Coefficient J:	0.000000E+0
Coefficient D:	7.802240E-13	Coefficient K:	0.000000E+0
Coefficient E:	-1.102127E-17	Coefficient L:	0.000000E+0
Coefficient F:	8.825508E-23	Coefficient M:	0.000000E+0
Coefficient G:	-2.295774E-28	Coefficient N:	0.000000E+0

Calibration Date (dd/mm/yyyy): 14/1/2016

Certified By:

Robert Haydock

President, AML Oceanographic

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Certificate of Conformity

Customer:	Rolls-Royce Canada Limited, Naval Marine
AML Reference Number:	Sales Order #32499
Customer PO Number:	131074-13097
Asset Serial Number:	008615
Asset Product Type:	Micro CTD, Titanium, MVP, with Extended Temp & Cond Range
Housing Depth Rating:	1000 dbar / meters
Additional Description:	

Certification Date (dd/mm/yyyy): 8/10/2013

Certified By:

AML Oceanographic

Robert Haydock
President
AML Oceanographic

AML Oceanographic certifies that the equipment described above has been tested in accordance with the product's technical specifications, brochures and / or relevant drawings. Housing depth rating refers to the maximum deployment depth of this instrument; on-board sensors may further restrict this range. AML Oceanographic certifies that calibrations on this instrument have been completed with equipment referenced to traceable standards.

Instrument configuration files and soft copy certificates are available at our on-line Customer Centre at www.AMLoceanographic.com/support

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Certificate of Calibration

Customer:	NOAA - Marine Operations Center Atlantic
Asset Serial Number:	008660
Asset Product Type:	Micro CTD, Titanium, MVP, with Extended Temp & Cond Range
Calibration Type:	Conductivity
Calibration Range:	0 to 79 mS/cm
Calibration RMS Error:	.004
Calibration ID:	008660 0B5626 500352 110814 142708
Installed On:	008660

Coefficient A:	-9.456471E-3	Coefficient H:	2.505721E-14
Coefficient B:	-4.276995E-7	Coefficient I:	0.000000E+0
Coefficient C:	3.520117E-9	Coefficient J:	0.000000E+0
Coefficient D:	-7.867964E-12	Coefficient K:	0.000000E+0
Coefficient E:	3.011615E-5	Coefficient L:	0.000000E+0
Coefficient F:	1.362100E-9	Coefficient M:	0.000000E+0
Coefficient G:	-1.121056E-11	Coefficient N:	0.000000E+0

Calibration Date (dd/mm/yyyy): 11/8/2014

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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Certificate of Calibration

Customer:	NOAA - Marine Operations Center Atlantic
Asset Serial Number:	008660
Asset Product Type:	Micro CTD, Titanium, MVP, with Extended Temp & Cond Range
Calibration Type:	Conductivity
Calibration Range:	0 to 79 mS/cm
Calibration RMS Error:	.004
Calibration ID:	008660 0B5626 500352 110814 142708
Installed On:	008660

Coefficient A:	-9.456471E-3	Coefficient H:	2.505721E-14
Coefficient B:	-4.276995E-7	Coefficient I:	0.000000E+0
Coefficient C:	3.520117E-9	Coefficient J:	0.000000E+0
Coefficient D:	-7.867964E-12	Coefficient K:	0.000000E+0
Coefficient E:	3.011615E-5	Coefficient L:	0.000000E+0
Coefficient F:	1.362100E-9	Coefficient M:	0.000000E+0
Coefficient G:	-1.121056E-11	Coefficient N:	0.000000E+0

Calibration Date (dd/mm/yyyy): 11/8/2014

Certified By:

AML Oceanographic

Robert Haydock

President, AML Oceanographic

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Certificate of Calibration

Customer:	NOAA - Marine Operations Center Atlantic
Asset Serial Number:	008660
Asset Product Type:	Micro CTD, Titanium, MVP, with Extended Temp & Cond Range
Calibration Type:	Conductivity
Calibration Range:	0 to 79 mS/cm
Calibration RMS Error:	.004
Calibration ID:	008660 0B5626 500352 110814 142708
Installed On:	008660

Coefficient A:	-9.456471E-3	Coefficient H:	2.505721E-14
Coefficient B:	-4.276995E-7	Coefficient I:	0.000000E+0
Coefficient C:	3.520117E-9	Coefficient J:	0.000000E+0
Coefficient D:	-7.867964E-12	Coefficient K:	0.000000E+0
Coefficient E:	3.011615E-5	Coefficient L:	0.000000E+0
Coefficient F:	1.362100E-9	Coefficient M:	0.000000E+0
Coefficient G:	-1.121056E-11	Coefficient N:	0.000000E+0

Calibration Date (dd/mm/yyyy): 11/8/2014

Certified By:

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SBE

SEA-BIRD ELECTRONICS, INC.

13431 NE 20th St. Bellevue, Washington 98005 USA

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

Service Report

RMA Number 86435N

Customer Information:

Company	Atlantic Marine Center
Date	1/22/2016
Contact	Thanh Loi
PO Number	TBD

Serial Number	19P32914-4480
Model Number	SBE 19Plus

Services Requested:

1. Evaluate/Repair Instrumentation.
2. Perform Routine Calibration Service.

Problems Found:

Services Performed:

1. Performed initial diagnostic evaluation.
2. Calibrated the pressure sensor.
3. Performed "Post Cruise" calibration of the temperature & conductivity sensors.
4. Performed complete system check and full diagnostic evaluation.

Special Notes:

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Conductivity Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	86435N	**Date of Report:**	1/12/2016
Model Number	SBE 19Plus	**Serial Number:**	19P32914-4480

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. 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: 1/12/2016 Drift since last cal: -0.00010 PSU/month*

Comments:

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

Date: Drift since Last cal: PSU/month*

Comments:

***Measured at 3.0 S/m**

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

Sea-Bird Electronics, Inc.

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Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 4480
CALIBRATION DATE: 12-Jan-16

SBE 19plus CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

```
g =  -9.833041e-001
h =   1.352032e-001
i =  -1.746279e-004
j =   3.287798e-005
```

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

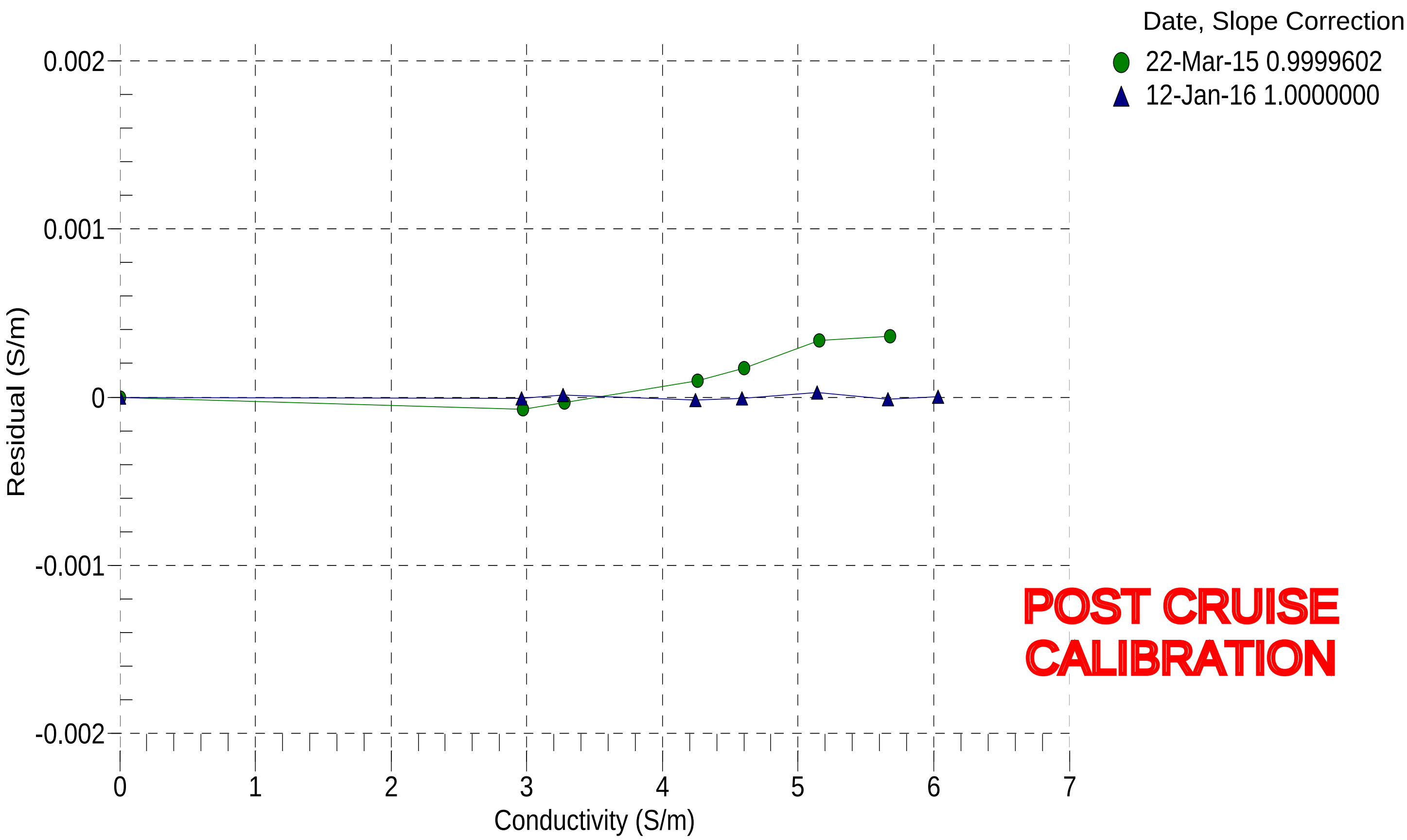
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2699.13	0.0000	0.00000
1.0000	34.6107	2.96006	5400.26	2.9601	-0.00001
4.5000	34.5927	3.26570	5604.88	3.2657	0.00001
15.0000	34.5549	4.24293	6213.17	4.2429	-0.00002
18.5000	34.5462	4.58639	6412.98	4.5864	-0.00001
24.0000	34.5361	5.14153	6723.08	5.1416	0.00003
29.0000	34.5320	5.66097	7000.42	5.6610	-0.00001
32.5000	34.5295	6.03161	7191.58	6.0316	0.00000

f = Instrument Output (Hz) / 1000.0

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

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) /10 (1 + \delta * t + \varepsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



POST CRUISE CALIBRATION

Sea-Bird Electronics, Inc.

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SENSOR SERIAL NUMBER: 4480
CALIBRATION DATE: 08-Jan-16

SBE 19plus PRESSURE CALIBRATION DATA
5076 psia S/N 3336

COEFFICIENTS:

```
PA0 =      1.272218e+000
PA1 =      1.569654e-002
PA2 =     -6.715534e-010
PTEMPA0 = -6.721580e+001
PTEMPA1 =  5.151440e+001
PTEMPA2 = -5.100431e-001
```

```
PTCA0 =  5.242189e+005
PTCA1 =  1.594674e+000
PTCA2 =  8.265540e-002
PTCB0 =  2.508287e+001
PTCB1 = -2.500000e-005
PTCB2 =  0.000000e+000
```

PRESSURE SPAN CALIBRATION

PRESSURE (PSIA)	INSTRUMENT OUTPUT (counts)	THERMISTOR OUTPUT (volts)	COMPUTED PRESSURE (PSIA)	RESIDUAL (%FSR)
14.64	525160.0	1.8	14.77	0.00
1114.89	595449.0	1.8	1114.68	-0.00
2114.86	659716.0	1.8	2114.55	-0.01
3114.68	724364.0	1.8	3114.76	0.00
4114.84	789368.0	1.8	4114.81	-0.00
5064.92	851458.0	1.8	5064.73	-0.00
4114.83	789382.0	1.8	4115.02	0.00
3114.71	724382.0	1.8	3115.04	0.01
2114.84	659737.0	1.8	2114.88	0.00
1114.93	595458.0	1.8	1114.82	-0.00
14.64	525158.0	1.8	14.73	0.00

THERMAL CORRECTION

TEMP (°C)	THERMISTOR OUTPUT (volts)	INSTRUMENT OUTPUT (counts)
32.50	1.97	525234.03
29.00	1.90	525210.10
24.00	1.80	525179.42
18.50	1.69	525152.05
15.00	1.62	525137.68
4.50	1.41	525103.81
1.00	1.34	525095.58

TEMPERATURE (°C)	SPAN (mV)
-5.00	25.08
35.00	25.08

y = thermistor output (counts)

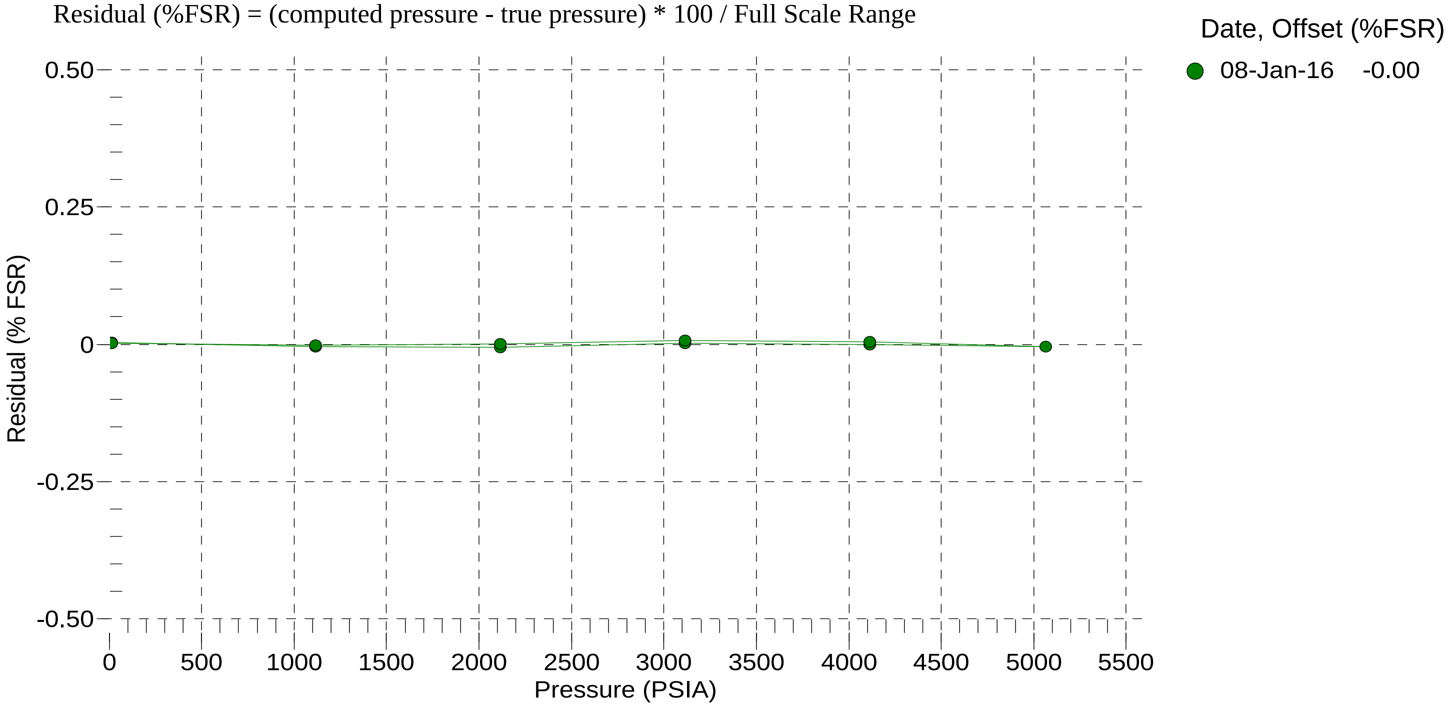
$t = PTEMPA0 + PTEMPA1 * y + PTEMPA2 * y^2$

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

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

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

Residual (%FSR) = (computed pressure - true pressure) * 100 / Full Scale Range



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SENSOR SERIAL NUMBER: 4480
CALIBRATION DATE: 12-Jan-16

SBE 19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:
a0 = 1.269875e-003
a1 = 2.564428e-004
a2 = 7.859616e-007
a3 = 1.180083e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
1.0000	619138.288	1.0000	0.0000
4.5000	549768.712	4.4999	-0.0001
15.0000	377664.542	14.9999	-0.0001
18.5000	331462.322	18.5002	0.0002
24.0000	268748.983	23.9999	-0.0001
29.0000	221011.237	28.9999	-0.0001
32.5000	192174.712	32.5001	0.0001

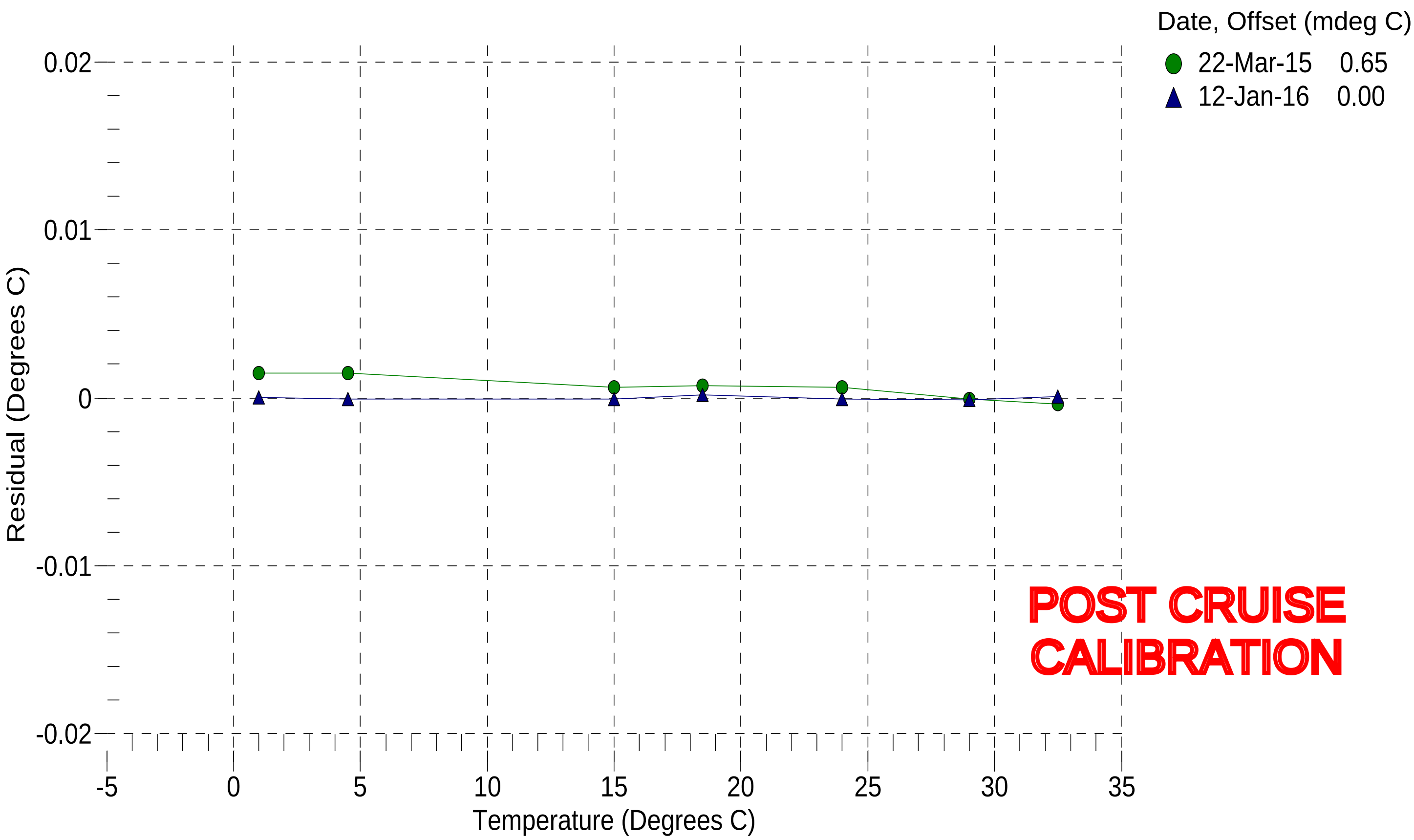
n = Instrument Output (counts)

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

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

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

Residual (°C) = instrument temperature - bath temperature



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Temperature Calibration Report

Customer:	Atlantic Marine Center
Job Number:	86435N
Date of Report:	1/12/2016
Model Number	SBE 19Plus
Serial Number:	19P32914-4480

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. 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: 1/12/2016 Drift since last cal: -0.00080 Degrees Celsius/year

Comments:

'CALIBRATION AFTER REPAIR' ☐ Performed ☑ Not Performed

Date: Drift since Last cal: Degrees Celsius/year

Comments:

SBE

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Service Report

RMA Number 86435N

Customer Information:

Company	Atlantic Marine Center	**Date**	1/22/2016
Contact	Thanh Loi		
PO Number	TBD		

Serial Number	19P36399-4642
Model Number	SBE 19Plus

Services Requested:

1. Evaluate/Repair Instrumentation.
2. Perform Routine Calibration Service.

Problems Found:

1. The switch magnet was found to have corrosion damage.

Services Performed:

1. Performed initial diagnostic evaluation.
2. Installed NEW switch magnet assembly.
3. Calibrated the pressure sensor.
4. Performed "Post Cruise" calibration of the temperature & conductivity sensors.
5. Performed complete system check and full diagnostic evaluation.

Special Notes:

SBE

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Conductivity Calibration Report

Customer:	Atlantic Marine Center

Job Number:	86435N	**Date of Report:**	1/12/2016
Model Number	SBE 19Plus	**Serial Number:**	19P36399-4642

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. 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: 1/12/2016 Drift since last cal: -0.00020 PSU/month*

Comments:

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

Date: Drift since Last cal: PSU/month*

Comments:

**Measured at 3.0 S/m*

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

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Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 4642
CALIBRATION DATE: 12-Jan-16

SBE 19plus CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

```
g = -1.024191e+000
h =  1.266662e-001
i =  7.221811e-005
j =  1.200735e-005

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

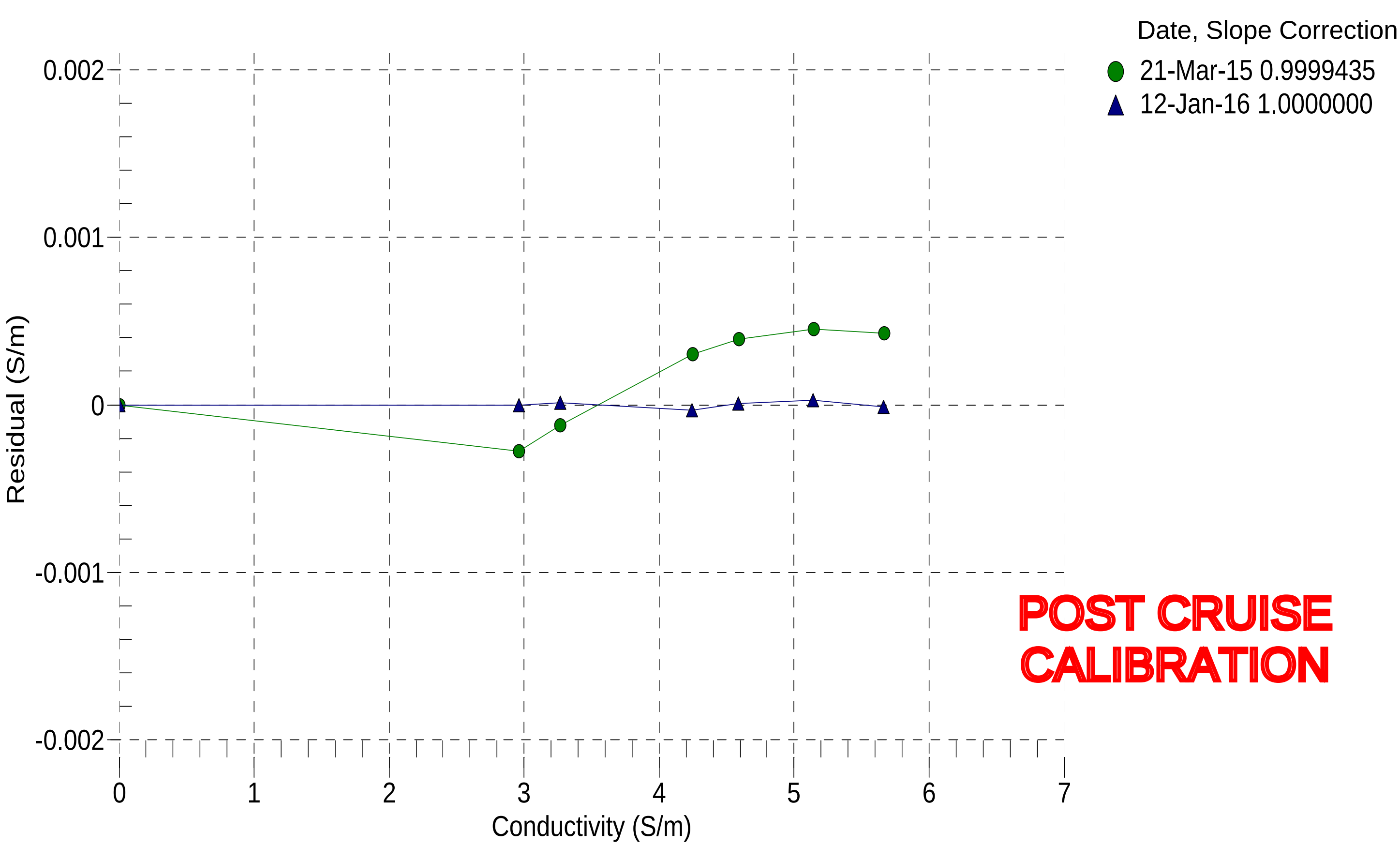
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2840.16	0.0000	0.00000
1.0000	34.6107	2.96006	5591.29	2.9601	-0.00000
4.5000	34.5927	3.26570	5800.82	3.2657	0.00001
15.0000	34.5549	4.24293	6424.28	4.2429	-0.00003
18.5000	34.5462	4.58639	6629.27	4.5864	0.00001
24.0000	34.5361	5.14153	6947.54	5.1416	0.00003
29.0000	34.5320	5.66097	7232.35	5.6610	-0.00001
32.5000	34.5295	6.03161	7428.56	6.0312	-0.00038

f = Instrument Output (Hz) / 1000.0

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

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) /10 (1 + \delta * t + \varepsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



POST CRUISE CALIBRATION

Sea-Bird Electronics, Inc.

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SENSOR SERIAL NUMBER: 4642
CALIBRATION DATE: 08-Jan-16

SBE 19plus PRESSURE CALIBRATION DATA
508 psia S/N 5632

COEFFICIENTS:

```
PA0 =      6.581024e-001
PA1 =      1.547891e-003
PA2 =      7.193046e-012
PTEMPA0 = -7.514541e+001
PTEMPA1 =  4.830836e+001
PTEMPA2 = -2.203947e-001
```

```
PTCA0 =  5.322959e+005
PTCA1 =  2.256678e+001
PTCA2 = -1.620840e-001
PTCB0 =  2.569025e+001
PTCB1 = -3.500000e-004
PTCB2 =  0.000000e+000
```

PRESSURE SPAN CALIBRATION

PRESSURE (PSIA)	INSTRUMENT OUTPUT (counts)	THERMISTOR OUTPUT (volts)	COMPUTED PRESSURE (PSIA)	RESIDUAL (%FSR)
14.64	541747.0	2.0	14.64	0.00
104.91	600028.0	2.0	104.90	-0.00
204.91	664558.0	2.0	204.91	-0.00
304.92	729042.0	2.0	304.91	-0.00
404.92	793494.0	2.0	404.91	-0.00
504.93	857910.0	2.0	504.92	-0.00
404.92	793514.0	2.0	404.94	0.00
304.93	729060.0	2.0	304.93	0.00
204.92	664574.0	2.0	204.93	0.00
104.92	600048.0	2.0	104.93	0.00
14.64	541755.0	2.0	14.64	-0.00

THERMAL CORRECTION

TEMP (°C)	THERMISTOR OUTPUT (volts)	INSTRUMENT OUTPUT (counts)
32.50	2.25	542116.64
29.00	2.18	542074.78
24.00	2.07	542005.74
18.50	1.96	541916.37
15.00	1.88	541857.41
4.50	1.66	541653.43
1.00	1.59	541578.71

TEMPERATURE (°C)	SPAN (mV)
-5.00	25.69
35.00	25.68

y = thermistor output (counts)

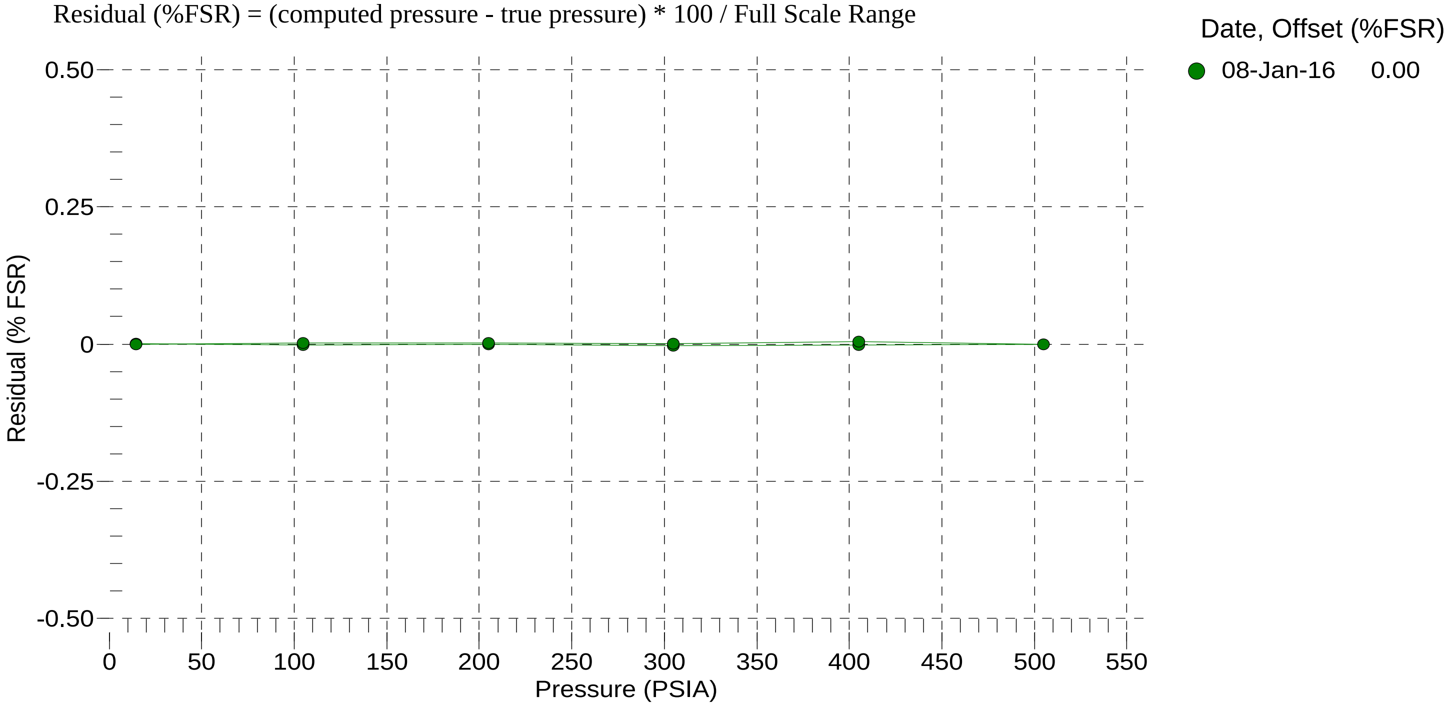
$t = PTEMPA0 + PTEMPA1 * y + PTEMPA2 * y^2$

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

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

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

Residual (%FSR) = (computed pressure - true pressure) * 100 / Full Scale Range



Sea-Bird Electronics, Inc.
13431 NE 20th Street, Bellevue, WA 98005-2010 USA
Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 4642
CALIBRATION DATE: 12-Jan-16

SBE 19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:
a0 = 1.184792e-003
a1 = 2.769344e-004
a2 = -1.221819e-006
a3 = 2.009333e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
1.0000	625326.780	1.0000	0.0000
4.5000	556563.966	4.4999	-0.0001
15.0000	385279.492	15.0000	0.0000
18.5000	339089.847	18.5001	0.0001
24.0000	276210.542	23.9999	-0.0001
29.0000	228181.881	29.0000	0.0000
32.5000	199092.915	32.5000	0.0000

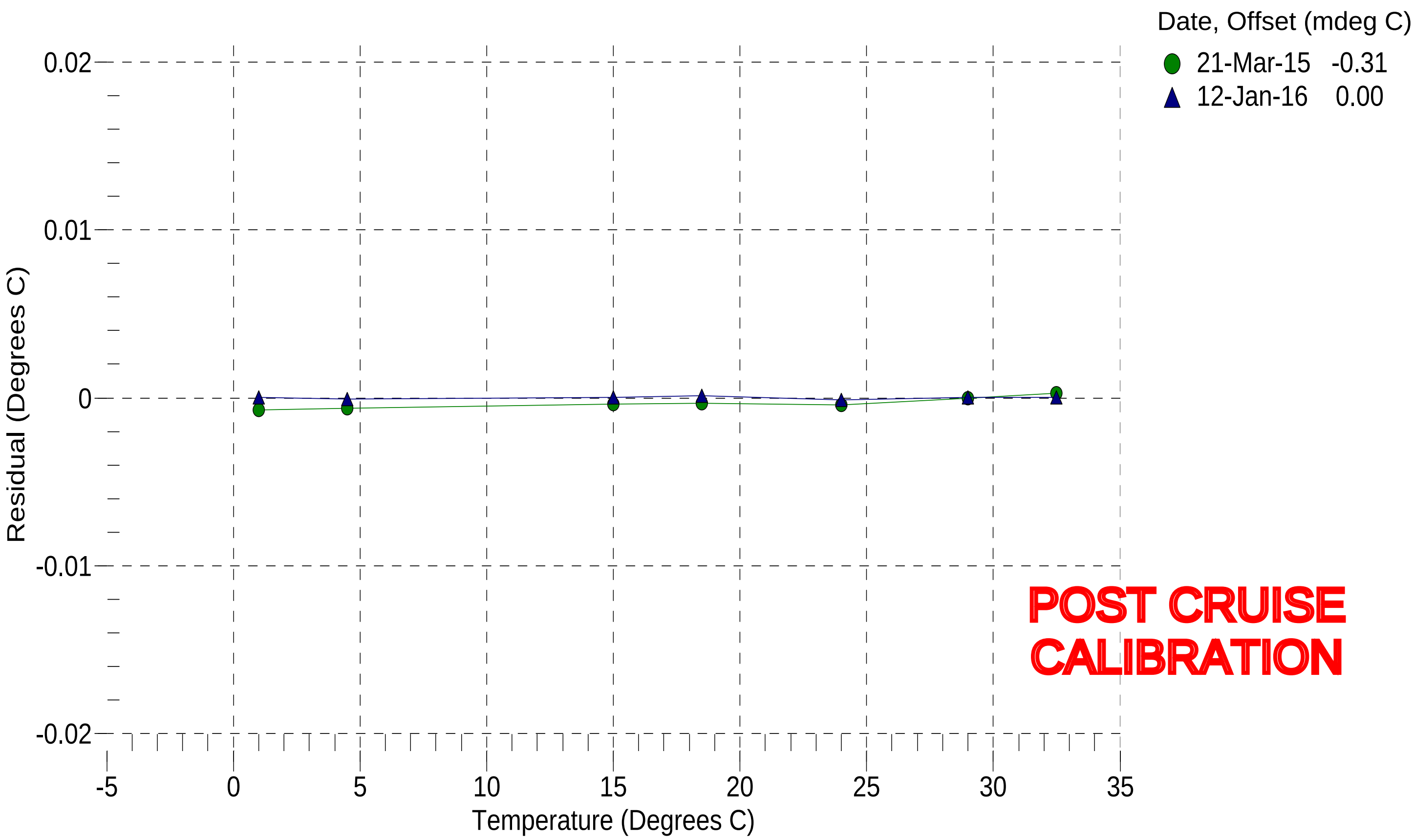
n = Instrument Output (counts)

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

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

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

Residual (°C) = instrument temperature - bath temperature



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Temperature Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	86435N	**Date of Report:**	1/12/2016
Model Number	SBE 19Plus	**Serial Number:**	19P36399-4642

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. 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: 1/12/2016 Drift since last cal: +0.00038 **Degrees Celsius/year**

Comments:

'CALIBRATION AFTER REPAIR' ☐ Performed ☑ Not Performed

Date: Drift since Last cal: **Degrees Celsius/year**

Comments:

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Service Report

RMA Number 86435N

Customer Information:

Company	Atlantic Marine Center
Date	1/22/2016
Contact	Thanh Loi
PO Number	TBD

Serial Number	19P65591-6918
Model Number	SBE 19Plus

Services Requested:

1. Evaluate/Repair Instrumentation.
2. Perform Routine Calibration Service.

Problems Found:

1. No comms upon arrival. The U21 component was found to be bad.

Services Performed:

1. Performed initial diagnostic evaluation.
2. Performed internal inspection and O-ring replacement.
3. Performed hydrostatic pressure test.
4. Calibrated the pressure sensor.
5. Performed "Post Cruise" calibration of the temperature & conductivity sensors.
6. Performed complete system check and full diagnostic evaluation.

Special Notes:

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Conductivity Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	86435N	**Date of Report:**	1/18/2016
Model Number	SBE 19Plus	**Serial Number:**	19P65591-6918

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. 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: 1/16/2016 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.

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SENSOR SERIAL NUMBER: 6918
CALIBRATION DATE: 16-Jan-16

SBE 19plus V2 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

```
g = -9.862473e-001
h =  1.555550e-001
i = -3.785908e-004
j =  5.253847e-005

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

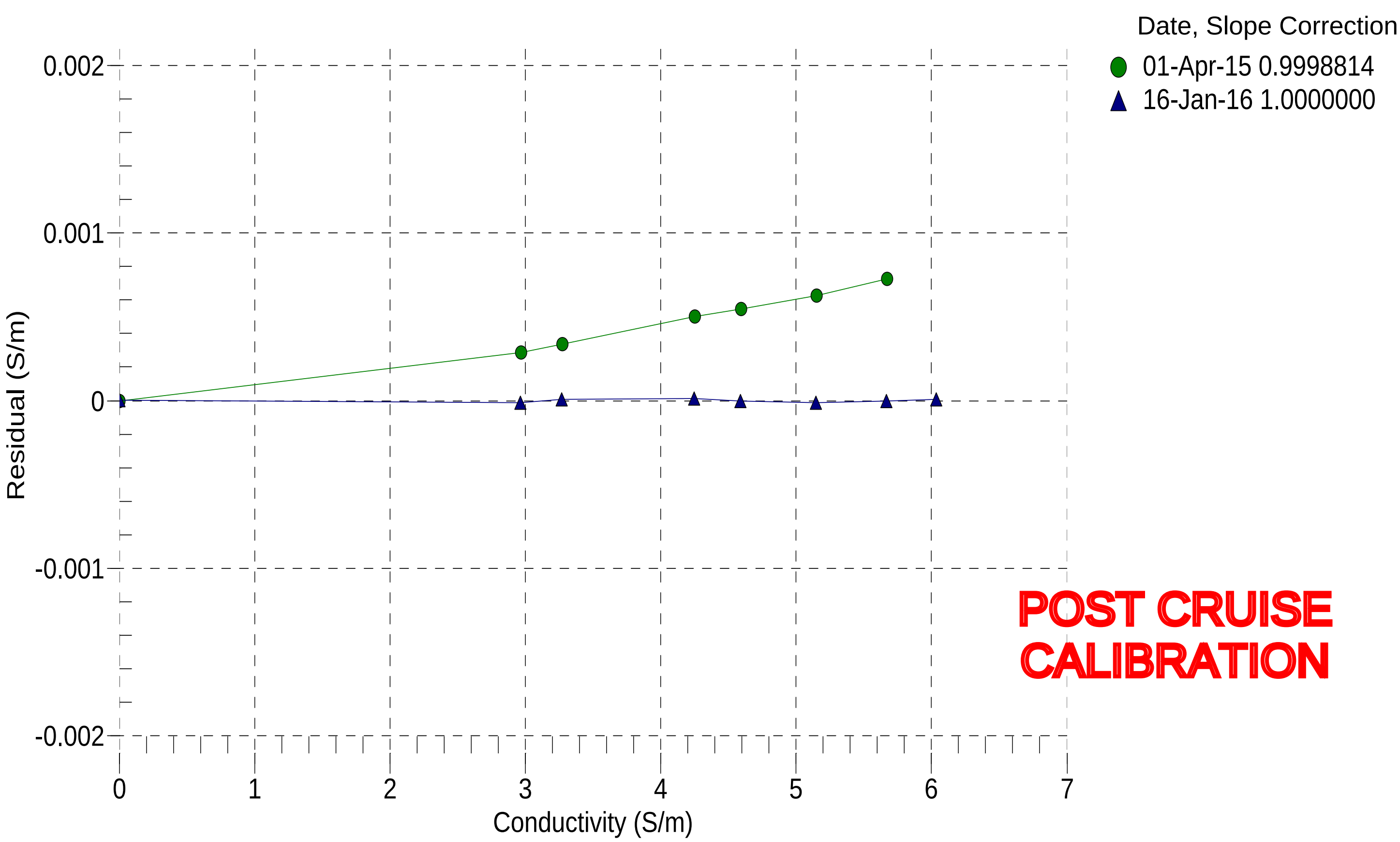
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2523.01	0.0000	0.00000
1.0000	34.6520	2.96326	5048.12	2.9632	-0.00001
4.4999	34.6323	3.26906	5239.42	3.2691	0.00001
15.0000	34.5899	4.24677	5808.17	4.2468	0.00001
18.5000	34.5812	4.59053	5995.06	4.5905	-0.00000
24.0000	34.5717	5.14625	6285.15	5.1462	-0.00001
29.0000	34.5669	5.66605	6544.54	5.6660	-0.00000
32.5000	34.5646	6.03704	6723.36	6.0371	0.00001

f = Instrument Output (Hz) / 1000.0

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

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) /10 (1 + \delta * t + \varepsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



POST CRUISE CALIBRATION

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SENSOR SERIAL NUMBER: 6918
CALIBRATION DATE: 13-Jan-16

SBE 19plus V2 PRESSURE CALIBRATION DATA
508 psia S/N 3313900

COEFFICIENTS:

```
PA0 =      7.710222e-002
PA1 =      1.547684e-003
PA2 =      7.017601e-012
PTEMPA0 = -5.538239e+001
PTEMPA1 =  5.427974e+001
PTEMPA2 = -2.598829e-001

PTCA0 =  5.245112e+005
PTCA1 =  4.210420e+000
PTCA2 = -1.040188e-001
PTCB0 =  2.490900e+001
PTCB1 = -1.400000e-003
PTCB2 =  0.000000e+000
```

PRESSURE SPAN CALIBRATION

PRESSURE (PSIA)	INSTRUMENT OUTPUT (counts)	THERMISTOR OUTPUT (volts)	COMPUTED PRESSURE (PSIA)	RESIDUAL (%FSR)
14.50	533864.0	1.4	14.51	0.00
104.77	592086.0	1.4	104.76	-0.00
204.78	656554.0	1.4	204.75	-0.01
304.78	720997.0	1.4	304.76	-0.00
404.78	785406.0	1.4	404.78	-0.00
504.79	849770.0	1.4	504.78	-0.00
404.79	785427.0	1.4	404.81	0.00
304.79	721032.0	1.4	304.81	0.00
204.79	656582.0	1.4	204.79	0.00
104.79	592120.0	1.4	104.81	0.00
14.51	533867.0	1.4	14.51	0.00

THERMAL CORRECTION

TEMP (°C)	THERMISTOR OUTPUT (volts)	INSTRUMENT OUTPUT (counts)
32.50	1.63	534094.54
29.00	1.57	534103.05
24.00	1.47	534110.55
18.50	1.37	534110.58
15.00	1.30	534106.91
4.50	1.11	534084.83
1.00	1.04	534072.70

TEMPERATURE (°C)	SPAN (mV)
-5.00	24.92
35.00	24.86

y = thermistor output (counts)

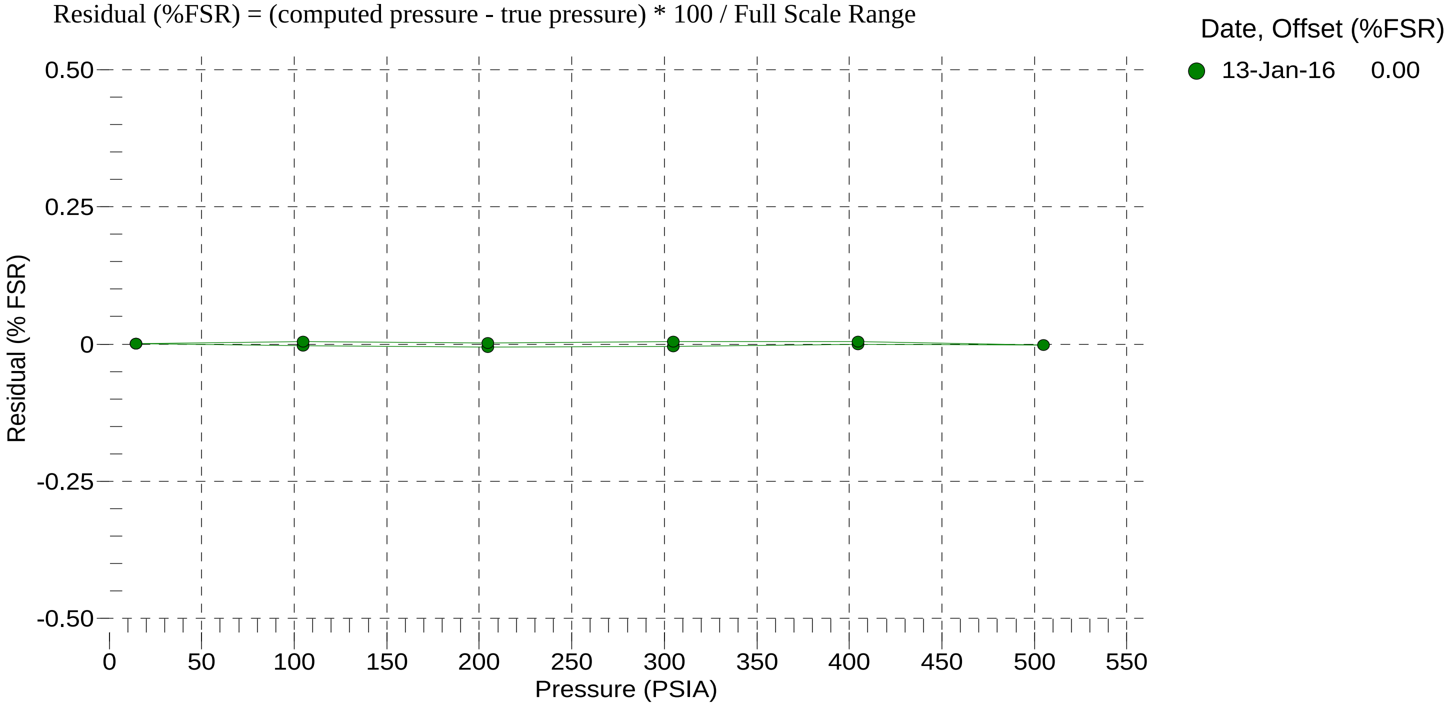
t = PTEMPA0 + PTEMPA1 * y + PTEMPA2 * y^2

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

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

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

Residual (%FSR) = (computed pressure - true pressure) * 100 / Full Scale Range



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SENSOR SERIAL NUMBER: 6918
CALIBRATION DATE: 16-Jan-16

SBE 19plus V2 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

```
a0 =  1.290840e-003
a1 =  2.693568e-004
a2 = -9.878554e-007
a3 =  1.738923e-007
```

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
1.0000	563963.644	0.9999	-0.0001
4.4999	497041.780	4.5000	0.0001
15.0000	333872.034	14.9999	-0.0001
18.5000	290815.186	18.4999	-0.0001
24.0000	232913.610	24.0000	0.0000
29.0000	189289.966	29.0001	0.0001
32.5000	163143.678	32.4999	-0.0001

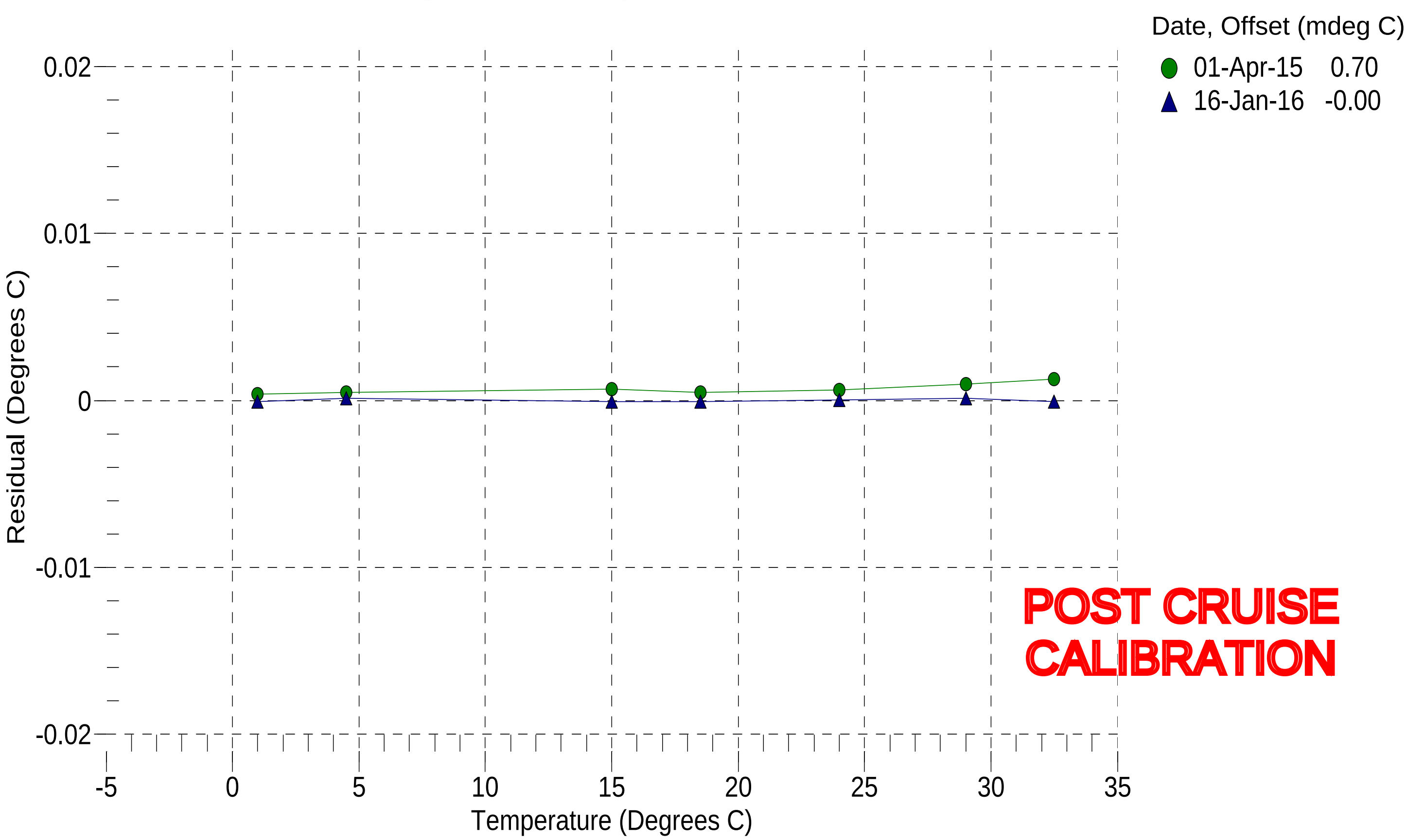
n = Instrument Output (counts)

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

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

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

Residual (°C) = instrument temperature - bath temperature



POST CRUISE CALIBRATION

SBE

SEA-BIRD ELECTRONICS, INC.
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Temperature Calibration Report

Customer:	Atlantic Marine Center
Job Number:	86435N
Date of Report:	1/18/2016
Model Number	SBE 19Plus
Serial Number:	19P65591-6918

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. 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: 1/16/2016 Drift since last cal: -0.00088 Degrees Celsius/year

Comments:

'CALIBRATION AFTER REPAIR' ☐ Performed ☑ Not Performed

Date: Drift since Last cal: Degrees Celsius/year

Comments:

SBE

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Conductivity Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	83595	**Date of Report:**	4/2/2015
Model Number	SBE 45	**Serial Number:**	4553332-0276

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. 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: 3/25/2015 Drift since last cal: -0.00660 PSU/month*

Comments:

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

Date: 4/2/2015 Drift since 19 Mar 14 +0.00160 PSU/month*

Comments:

**Measured at 3.0 S/m*

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

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SENSOR SERIAL NUMBER: 0276
CALIBRATION DATE: 02-Apr-15

SBE 45 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

```
g = -1.000781e+000
h =  1.569345e-001
i = -2.371795e-004
j =  4.448887e-005

CPcor = -9.5700e-008
CTcor =  3.2500e-006
WBOTC =  4.2855e-007
```

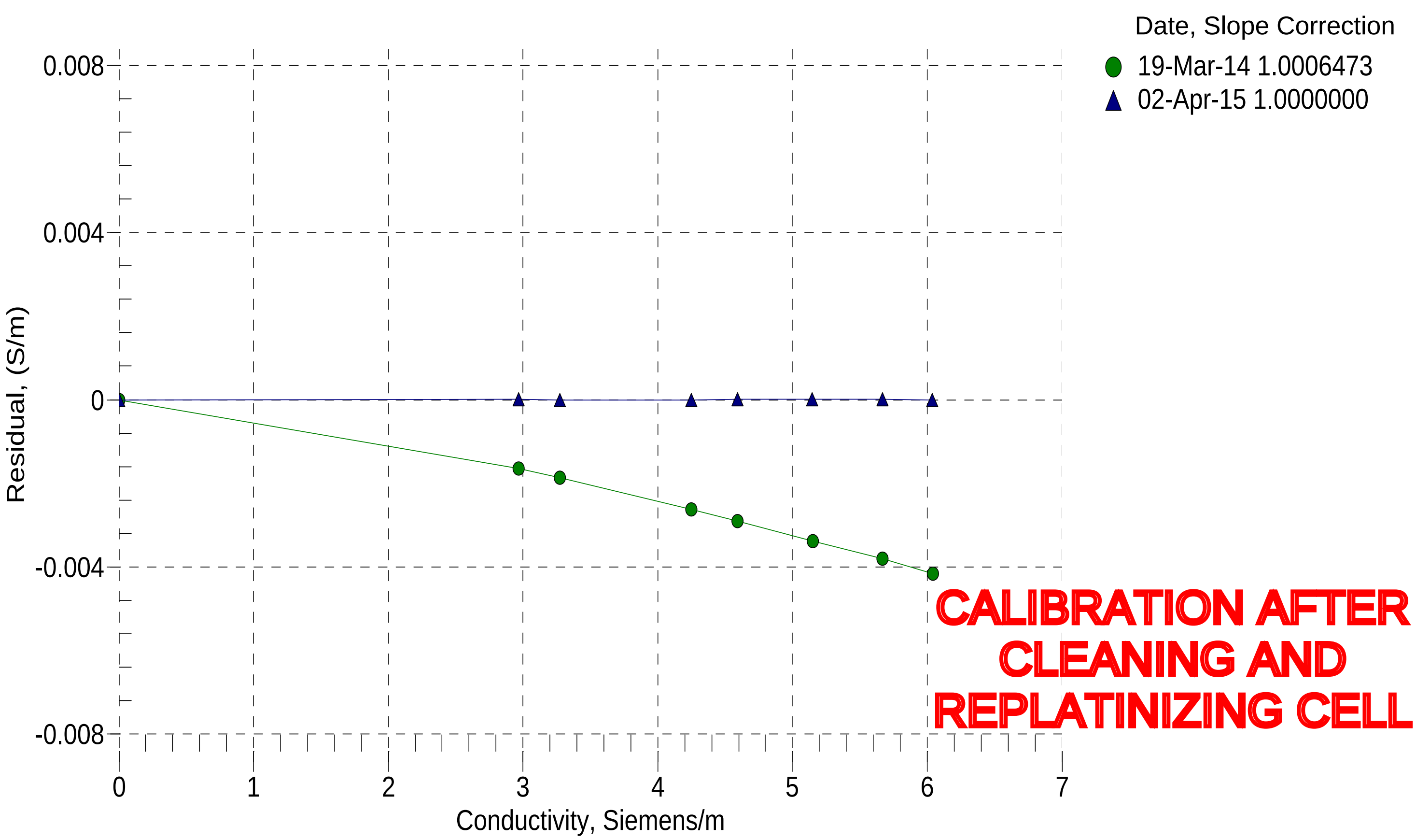
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2527.81	0.00000	0.00000
1.0000	34.6697	2.96463	5027.82	2.96463	0.00001
4.5000	34.6499	3.27057	5217.49	3.27056	-0.00000
15.0000	34.6072	4.24867	5781.55	4.24866	-0.00001
18.4999	34.5981	4.59253	5966.93	4.59253	0.00000
24.0000	34.5881	5.14842	6254.71	5.14843	0.00001
29.0000	34.5829	5.66838	6512.06	5.66838	0.00000
32.5000	34.5803	6.03947	6689.49	6.03947	-0.00000

f = INST FREQ * sqrt(1.0 + WBOTC * t) / 1000.0

Conductiv ity = $(g + h * f^2 + i * f^3 + j * f^4) / (1 + \delta * t + \varepsilon * p)$ Siemens / meter

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

Residual = instrument conductivity - bath conductivity



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SENSOR SERIAL NUMBER: 0276
CALIBRATION DATE: 25-Mar-15

SBE 45 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

```
g = -1.009654e+000
h =  1.597590e-001
i = -1.025941e-003
j =  1.153514e-004

CPcor = -9.5700e-008
CTcor =  3.2500e-006
WBOTC =  4.2855e-007
```

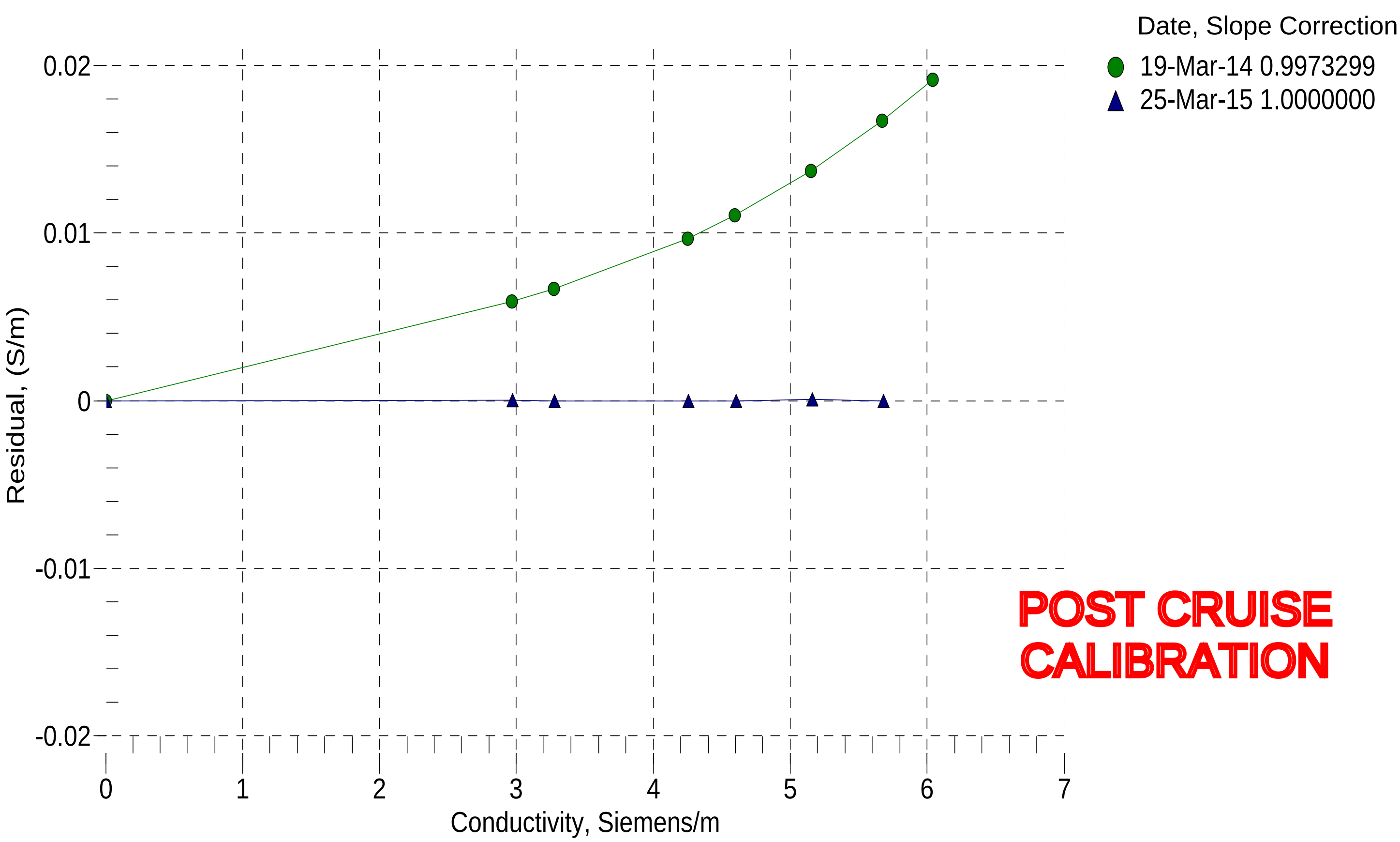
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2528.66	0.00000	0.00000
1.0000	34.7572	2.97139	5027.34	2.97144	0.00005
4.5000	34.7372	3.27800	5216.82	3.27795	-0.00004
15.0000	34.6945	4.25825	5780.06	4.25821	-0.00004
18.5000	34.6851	4.60284	5965.01	4.60284	-0.00000
23.9999	34.6747	5.15988	6251.92	5.15996	0.00008
29.0000	34.6686	5.68084	6508.16	5.68080	-0.00004
32.5000	34.6643	6.05248	6684.37	6.05184	-0.00064

f = INST FREQ * sqrt(1.0 + WBOTC * t) / 1000.0

Conductivity = $(g + h * f^2 + i * f^3 + j * f^4) / (1 + \delta * t + \varepsilon * p)$ Siemens / meter

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

Residual = instrument conductivity - bath conductivity



POST CRUISE CALIBRATION

Sea-Bird Electronics, Inc.

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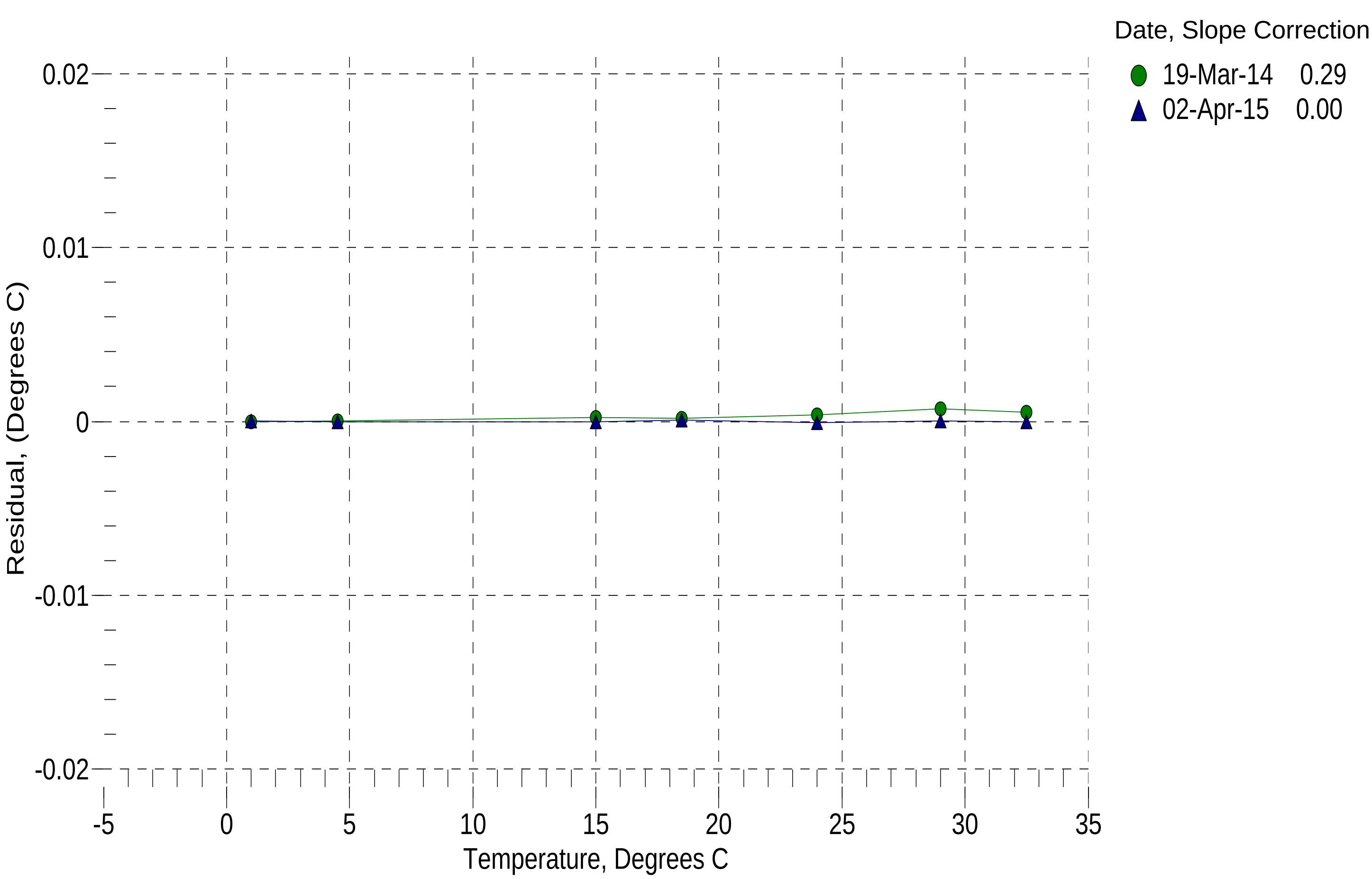
SENSOR SERIAL NUMBER: 0276
CALIBRATION DATE: 02-Apr-15

SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:
a0 = 5.804378e-005
a1 = 2.697794e-004
a2 = -2.132790e-006
a3 = 1.422788e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	695531.4	1.0000	0.0000
4.5000	593246.7	4.5000	-0.0000
15.0000	375471.7	15.0000	-0.0000
18.4999	324402.1	18.5000	0.0001
24.0000	259368.8	23.9999	-0.0001
29.0000	212934.6	29.0000	0.0000
32.5000	186093.8	32.5000	-0.0000

Temperature ITS-90 = $1/\{a0 + a1[ln(n)] + a2[ln^2(n)] + a3[ln^3(n)]\} - 273.15$ (°C)
Residual = instrument temperature - bath temperature
n = instrument output



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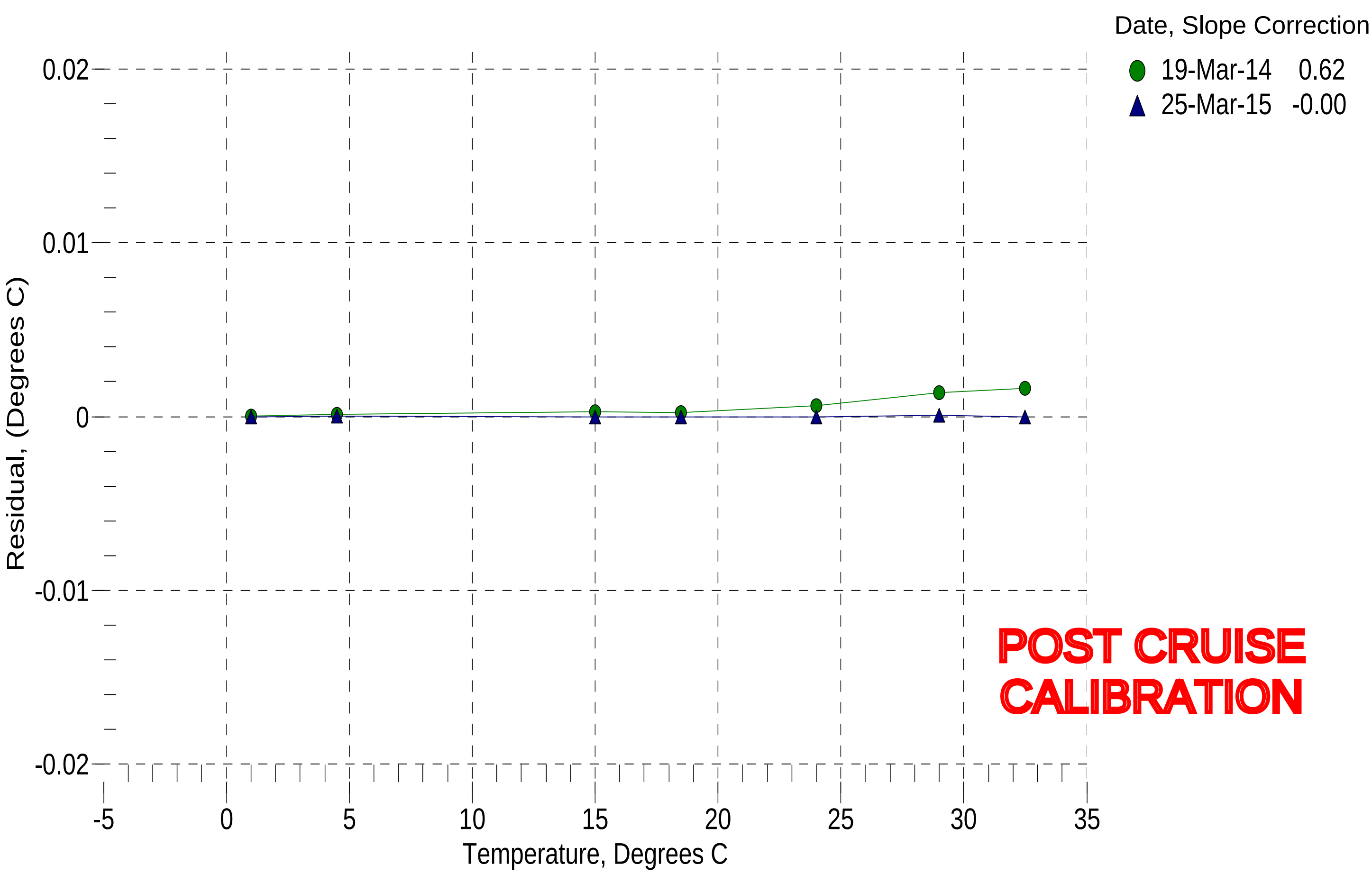
SENSOR SERIAL NUMBER: 0276
CALIBRATION DATE: 25-Mar-15

SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:
```
a0 =  1.670173e-005
a1 =  2.793181e-004
a2 = -2.866220e-006
a3 =  1.610718e-007
```

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	695533.7	1.0000	-0.0000
4.5000	593248.4	4.5000	0.0000
15.0000	375472.6	15.0000	-0.0000
18.5000	324403.0	18.5000	-0.0000
23.9999	259371.7	23.9999	-0.0000
29.0000	212939.7	29.0001	0.0001
32.5000	186101.7	32.5000	-0.0000

Temperature ITS-90 = $1/\{a0 + a1[\mathit{ln}(n)] + a2[\mathit{ln}^2(n)] + a3[\mathit{ln}^3(n)]\} - 273.15$ (°C)
Residual = instrument temperature - bath temperature
n = instrument output



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:	83595	**Date of Report:**	4/2/2015
Model Number	SBE 45	**Serial Number:**	4553332-0276

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. 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: 3/25/2015 Drift since last cal: -0.00061 **Degrees Celsius/year**

Comments:

'FINAL CALIBRATION' ☑ Performed ☐ Not Performed

Date: 4/2/2015 Drift since 19 Mar 14 -0.00028 **Degrees Celsius/year**

Comments:

SEA-BIRD ELECTRONICS, INC.

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

Conductivity Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	83595	**Date of Report:**	4/2/2015
Model Number	SBE 45	**Serial Number:**	4553332-0277

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. 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: 3/25/2015 Drift since last cal: -0.00340 PSU/month*

Comments:

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

Date: 4/2/2015 Drift since 08 Mar 14 +0.00010 PSU/month*

Comments:

**Measured at 3.0 S/m*

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

Sea-Bird Electronics, Inc.

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

Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0277
CALIBRATION DATE: 02-Apr-15

SBE 45 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

```
g = -9.767505e-001
h =  1.532256e-001
i = -2.543499e-004
j =  4.442261e-005

CPcor = -9.5700e-008
CTcor =  3.2500e-006
WBOTC =  4.2855e-007
```

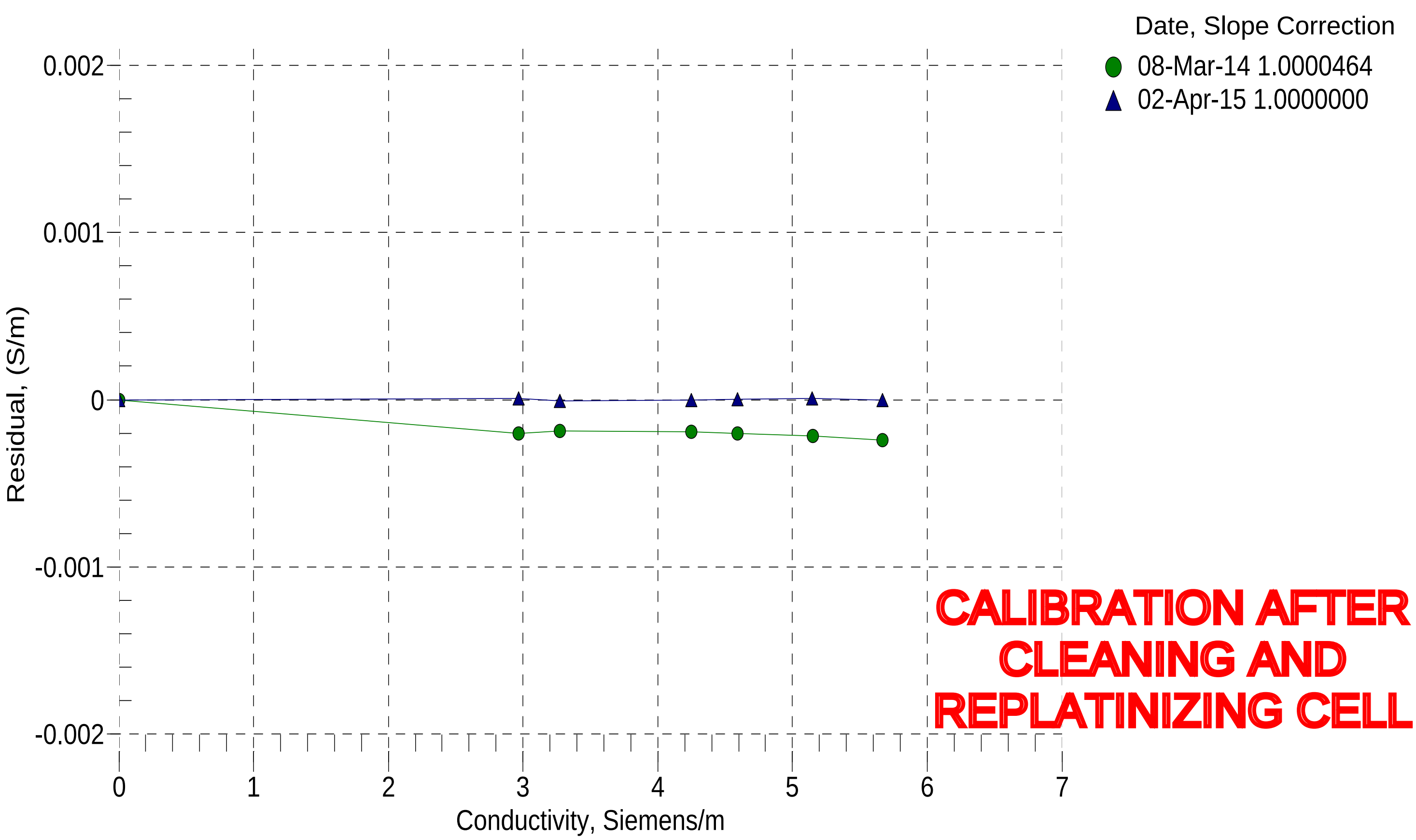
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2527.75	0.00000	0.00000
1.0000	34.6697	2.96463	5074.20	2.96463	0.00001
4.5000	34.6499	3.27057	5266.78	3.27056	-0.00001
15.0000	34.6072	4.24867	5839.29	4.24866	-0.00000
18.4999	34.5981	4.59253	6027.38	4.59253	0.00000
24.0000	34.5881	5.14842	6319.31	5.14843	0.00001
29.0000	34.5829	5.66838	6580.32	5.66837	-0.00000
32.5000	34.5803	6.03947	6760.30	6.03957	0.00010

f = INST FREQ * sqrt(1.0 + WBOTC * t) / 1000.0

Conductiv ity = $(g + h * f^2 + i * f^3 + j * f^4) / (1 + \delta * t + \varepsilon * p)$ Siemens / meter

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

Residual = instrument conductivity - bath conductivity



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Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0277
CALIBRATION DATE: 25-Mar-15

SBE 45 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -9.794501e-001
h = 1.538290e-001
i = -3.630906e-004
j = 5.289356e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006
WBOTC = 4.2855e-007

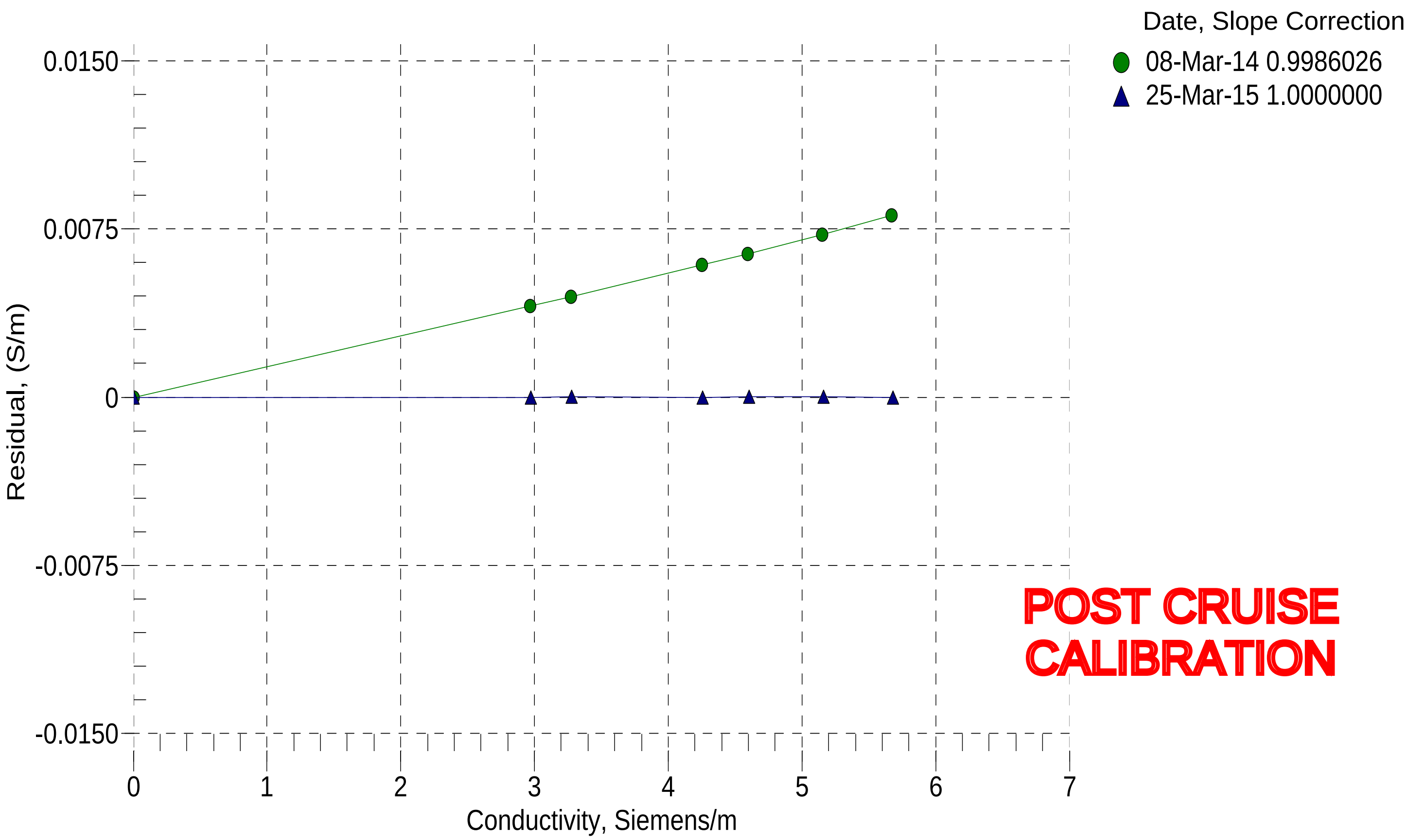
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2528.08	0.00000	0.00000
1.0000	34.7572	2.97139	5075.81	2.97139	-0.00001
4.5000	34.7372	3.27800	5268.50	3.27801	0.00001
15.0000	34.6945	4.25825	5841.23	4.25823	-0.00002
18.5000	34.6851	4.60284	6029.38	4.60285	0.00001
23.9999	34.6747	5.15988	6321.35	5.15988	0.00001
29.0000	34.6686	5.68084	6582.35	5.68084	-0.00000
32.5000	34.6643	6.05248	6762.20	6.05253	0.00006

f = INST FREQ * sqrt(1.0 + WBOTC * t) / 1000.0

Conductivity = $(g + h * f^2 + i * f^3 + j * f^4) / (1 + \delta * t + \varepsilon * p)$ Siemens / meter

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

Residual = instrument conductivity - bath conductivity



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SENSOR SERIAL NUMBER: 0277
CALIBRATION DATE: 02-Apr-15

SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

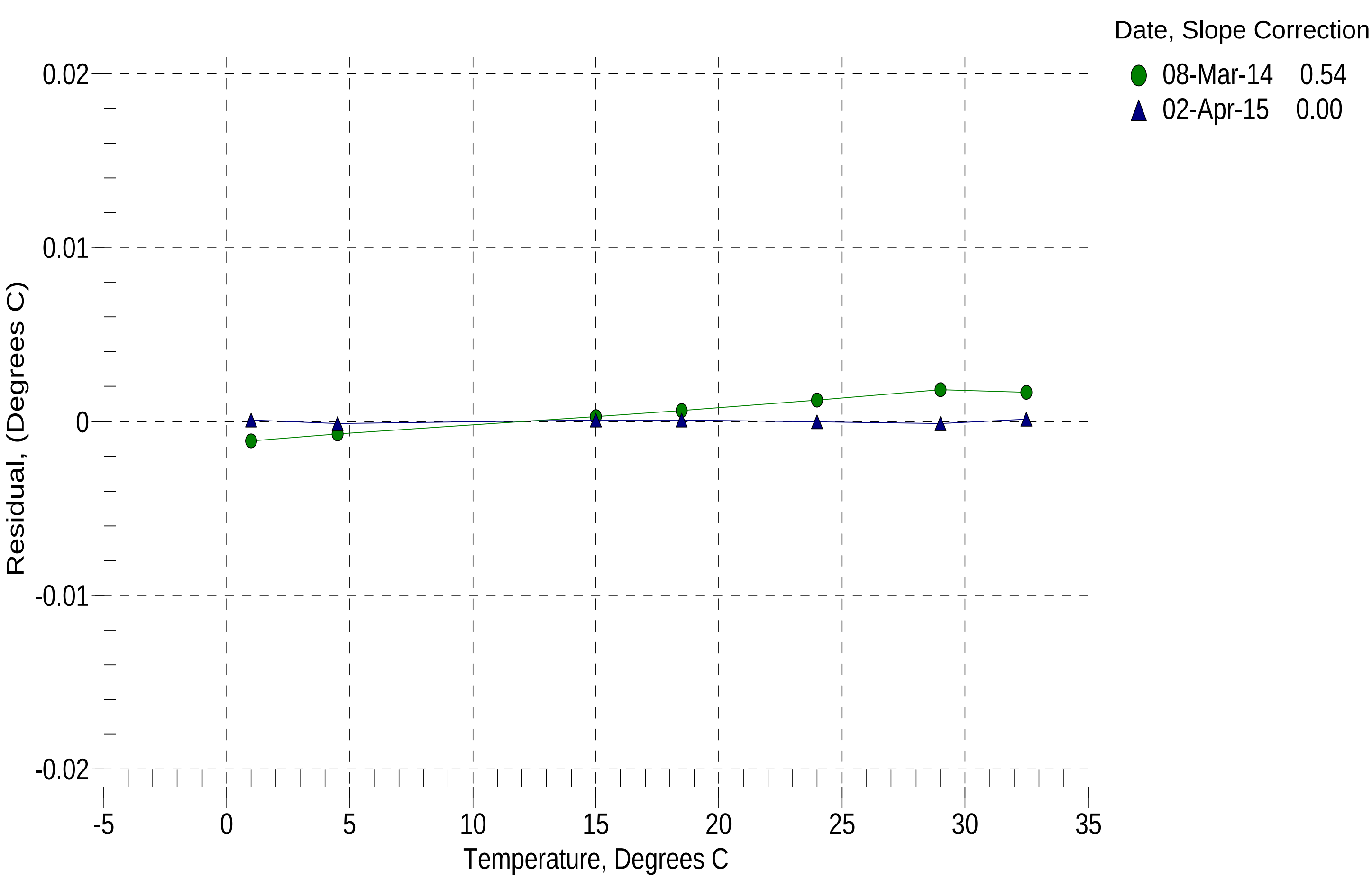
COEFFICIENTS:
a0 = 8.931750e-005
a1 = 2.676627e-004
a2 = -1.972607e-006
a3 = 1.393936e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	638596.3	1.0001	0.0001
4.5000	544690.2	4.4999	-0.0001
15.0000	344735.8	15.0001	0.0001
18.4999	297846.3	18.5000	0.0001
24.0000	238133.4	24.0000	-0.0000
29.0000	195499.7	28.9999	-0.0001
32.5000	170852.3	32.5001	0.0001

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

Residual = instrument temperature - bath temperature

n = instrument output



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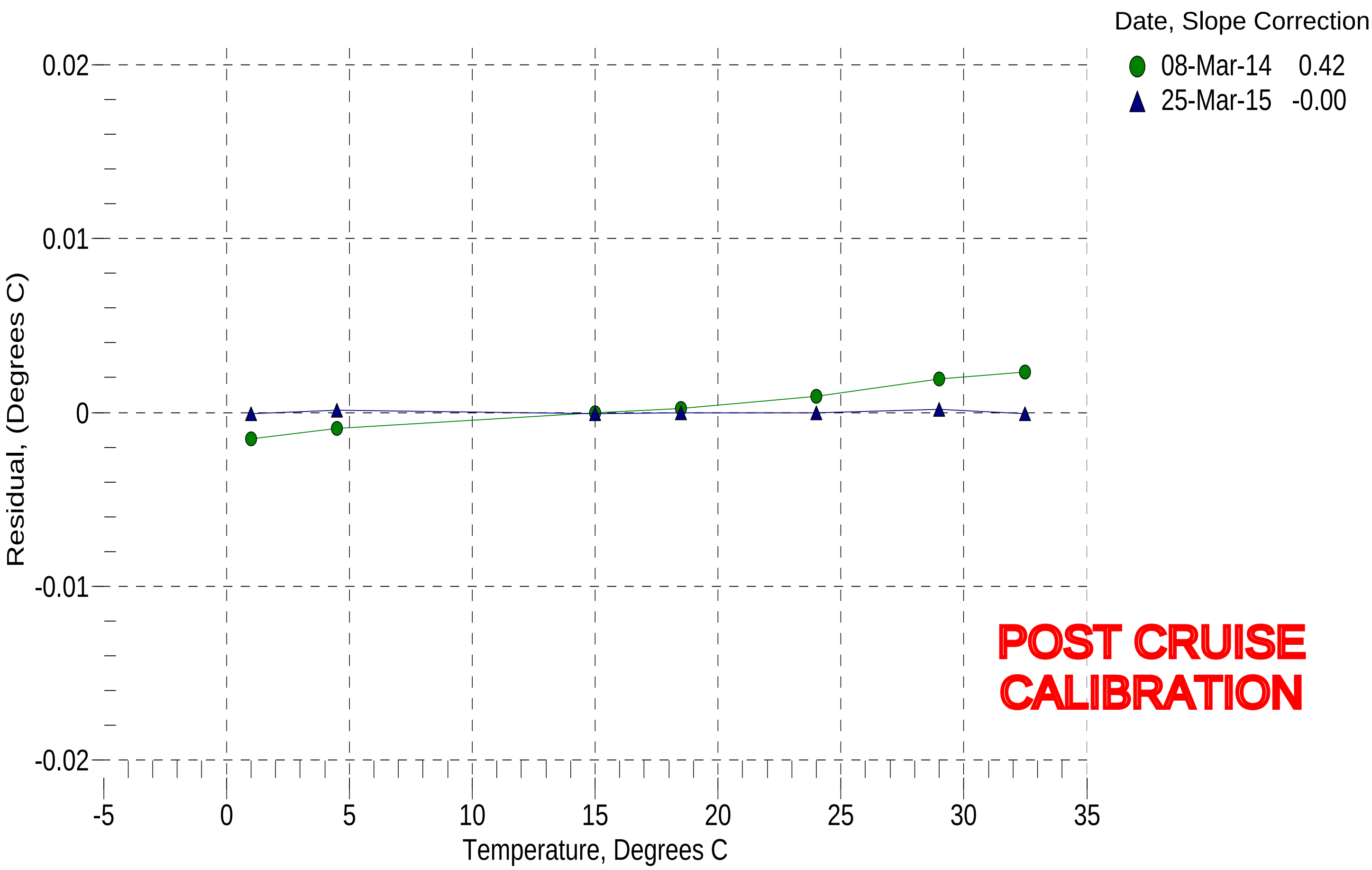
SENSOR SERIAL NUMBER: 0277
CALIBRATION DATE: 25-Mar-15

SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:
a0 = 1.717778e-005
a1 = 2.845634e-004
a2 = -3.291842e-006
a3 = 1.737056e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	638588.2	0.9999	-0.0001
4.5000	544679.5	4.5001	0.0001
15.0000	344732.9	14.9999	-0.0001
18.5000	297841.7	18.5000	-0.0000
23.9999	238131.4	23.9999	-0.0000
29.0000	195498.1	29.0002	0.0002
32.5000	170857.9	32.4999	-0.0001

Temperature ITS-90 = $1/\{a0 + a1[ln(n)] + a2[ln^2(n)] + a3[ln^3(n)]\} - 273.15$ (°C)
Residual = instrument temperature - bath temperature
n = instrument output



POST CRUISE CALIBRATION

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:	83595	**Date of Report:**	4/2/2015
Model Number	SBE 45	**Serial Number:**	4553332-0277

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. 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: 3/25/2015 Drift since last cal: -0.00040 Degrees Celsius/year

Comments:

'FINAL CALIBRATION' ☑ Performed ☐ Not Performed

Date: 4/2/2015 Drift since 08 Mar 14 -0.00050 Degrees Celsius/year

Comments:

seatronics

Worldwide rental of Marine Electronic Equipment
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Calibration Certificate Number: SH16797

This document certifies that the instrument detailed below has been calibrated according to Valeport Limited's Standard Procedures, using equipment with calibrations traceable to UKAS or National Standards.

Instrument Type:	miniSVS - SV only
Instrument Serial Number:	48002
Calibrated By:	B. Scott
Date:	21-Jan-16
Signed:	
QA Check:	

Full details of the results from the calibration procedure applied to each fitted sensor are available in separate documents. This summary certificate should be kept with the instrument.

an ACTEON company

Calibrated in a Valeport approved facility
Seatronics Inc.
1319 W. Sam Houson Pkwy N.
Suite 150
Houston, TX 77043
Tel:(713) 464-3311 Fax:(713) 464-6111

Build and Calibration Record - 652804C

Instrument type	miniSVS - SV only
Serial number	48002
Path Length, mm	100
Baud rate set ex factory	19200

Calibration History:	Certificate	Date
	SH16797	21-Jan-16

System Components	As Received				Modification				Modification				Modification			
	Part	Iss	Serial Number	Range / Firmware	Part	Iss	Serial Number	Range / Firmware	Part	Iss	Serial Number	Range / Firmware	Part	Iss	Serial Number	Range / Firmware
Main Board	0650505	E	101609	0650713B5 0650714C												
SV Sensor			101659													
Bootloader Fitted	YES															

Name B. Scott	Name	Name	Name
Date 21-Jan-16	Date	Date	Date
Signed B Scott	Signed	Signed	Signed

Calibrated to Valeport's procedures using test equipment with calibrations traceable to UKAS or national standards

Instrument Serial Number	48002
Transducer Type, mm	100
Transducer Ser No	101659
PCB Part No	0650505E
PCB Ser No	101609
Processor Firmware Version	0650713B5
FPGA Firmware Version	0650714C
Certificate Number	SH16797

Calibration Equipment used		
Instrument	Type	Serial No
Temp Bridge	MicroK 400	08-PO51 ITL271940/1
PRT	Isotech 909L	909L/141

Stage 1: First order fit

Temp °C90	SoS from Bilaniuk & Wong m/s	Measured ToF nsec*100	Coefficients	Calc SoS from coefficients m/s	Error (Calc - True) m/s	Acceptable Error m/s	Pass/Fail
2.3407	1413.867	14480437	3.844800E+05	1413.867	0.000	±0.001	Pass
14.3011	1463.474	14002626	5.017611E+06	1463.474	0.000	±0.001	Pass

Stage 2: Enter calibration string

#022;5017611;384480

Stage 3: Check point

Temp °C90	Actual SoS m/s	Measured SoS m/s	Error SoS Reading-Actual m/s	Acceptable Error m/s	Pass/Fail
2.3393	1413.860	1413.859	-0.001	±0.005	Pass

Name:	B. Scott
Date:	21-Jan-16
Signature:	B Scott

Calibrated to Valeport's procedures using test equipment with calibrations traceable to UKAS or national standards

TELEDYNE RESON
Everywhereyoulook™

SVP Test and Calibration certificate

Valid for surface use*

SVP Type :	SVP70
SVP Serial No.	2011276

Date of issue :	24-03-2015

Temperature Calibration :	Hart 1504 s/n A6B554 & Thermistor s/n 3014
Point 1:	4.6 ℃
Point 2:	16.6 ℃
Point 3:	25.6 ℃

	RMS Speed of Sound Errors
Temperature Validation :	0.0032 m/s

Calibration & Final Function Test : Sign : Find Petersen

QA Signature : Inits : Oslin
2015.03.24

* Surface use: 0 to 20m water depth.

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