U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Ocean Service

Data Acquisition & Processing Report

Type of Survey:	Navigable Area
Project Number:	OPR-G329-TJ-17
Time Frame:	August - November 2017

LOCALITY

State(s):	Georgia South Carolina
General Locality:	Approaches to Savannah River

2017

CHIEF OF PARTY
CDR Chris van Westendorp, NOAA

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Date:

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NOAA Ship *Thomas Jefferson*
Chief of Party: CDR Chris van Westendorp, NOAA
Year: 2017
Version: 2.0
Publish Date: 2018-01-23

A System Equipment and Software

A.1 Survey Vessels

A.1.1 NOAA Ship THOMAS JEFFERSON (WTEA)

Vessel Name	NOAA Ship THOMAS JEFFERSON (WTEA)	
Hull Number	S222	
Description	S222 is a steel hulled hydrographic survey ship built by Halter Marine, Inc., Moss Point, MS.	
Dimensions	*LOA*	208 ft
	Beam	45 ft
	Max Draft	17 ft
Most Recent Full Static Survey	*Date*	2016-09-01
	Performed By	The IMTEC Group, Ltd.

A.1.2 Hydrographic Survey Launch 2903 (HSL 2903)

Vessel Name	Hydrographic Survey Launch 2903 (HSL 2903)	
Hull Number	2903	
Description	HSL 2903 is an aluminum hulled hydrographic survey launch built in 2017 by Willard Marine, Inc. HSL 2903 is equipped to collect bathymetric data, side scan imagery, and water column profiles.	
Dimensions	*LOA*	28 ft
	Beam	10 ft
	Max Draft	4 ft

Most Recent Full Static Survey	*Date*	2017-05-01
	Performed By	National Ocean Service - National Geodetic Survey (NGS) - Field Operations Branch

A.2 Echo Sounding Equipment

A.2.1 Multibeam Echosounders

A.2.1.1 Kongsberg EM2040

Manufacturer	Kongsberg			
Model	EM2040			
Description	The Kongsberg EM2040 MBES is a high resolution shallow water MBES. It is capable of operating at 200, 300, and 400 kHz. Across-track swath width is up to 5.5 times water depth. The EM2040 is operated with a 90 degree swath width and in Single Center Sector mode per HSTB recommendations.			
Inventory	*S222*	*Component*	Processer	Transceiver
		Model Number	N/A	N/A
		Serial Number	CZC3410L1L	40072
		Frequency	N/A	300 khz
		Calibration	2017-07-01	2017-07-01
		Accuracy Check	2017-07-01	2017-07-01

A.2.1.2 Teledyne Reson (formerly RESON A/S) SeaBat 7125-SV2

Manufacturer	Teledyne Reson (formerly RESON A/S)
Model	SeaBat 7125-SV2

<table>
<tr><td>Description</td><td>The Reson SeaBat 7125-SV2 is a dual frequency (200/400kHz), high-resolution multibeam echo sounder system for shallow-water depths. The recommended maximum range at 200kHz is 450m resulting in a 225 m depth limit for full swath coverage on a flat bottom. The 400kHz setting maximum range is 175m resulting in a 87m depth limit for full swath coverage on a flat bottom. The transducer assembly consists of single flat-faced receiver array and one curved projector, which can transmit at either 200kHz or 400kHz. Bathymetric data from the 7125 SV2 is used to provide object detection and complete coverage in shallow water.

SeaBat 7125-SV2 systems are installed on HSLs 2903 and 2904. The integrated system includes a dual 200kHz & 400 kHz projector unit, a receiver unit, and a topside 7-P Sonar Processor Unit (TPU). The projector and receiver are set up in a Mills Cross configuration. The 7125-SV2 produces a across track swath of 140° in equidistant mode and 165° in equi-angle mode. At 200kHz the across track transmit swath is resolved into 256 discrete beams by the receive array. Each beam is has a resolution of 2° across track and 1° along track. At 400kHz the across track swath is resolved into 512 discrete beams by the receive array. Each beam has a resolution of 1° across track and 0.5° along track. The Reson 7125-SV2 can be configured for roll stabilization. In roll-stabilized mode, the sonar can operate in environments with up to +/- 10 degrees of roll without degrading system performance. Sound velocity at the face of the transducer is provided by an integrated Reson SVP-71 sound velocimeter. The TPU has the following software versions installed: 7K Center: 7K Center Version # 6.1.0.3, 7K UI Version 6.1.0.3, 7K IO Version 4.2.0.5.</td></tr>
<tr><td>Inventory</td><td><table><tr><td>2903</td><td><table>
<tr><td>Component</td><td>Processor</td><td>Receiver</td><td>Projector</td></tr>
<tr><td>Model Number</td><td>7125 SV2</td><td>EM 7216</td><td>TC 2181</td></tr>
<tr><td>Serial Number</td><td>18341313046</td><td>1513550</td><td>0513045</td></tr>
<tr><td>Frequency</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Calibration</td><td>2017-07-01</td><td>2017-07-01</td><td>2017-07-01</td></tr>
<tr><td>Accuracy Check</td><td>2017-07-01</td><td>2017-07-01</td><td>2017-07-01</td></tr>
</table></td></tr></table></td></tr>
</table>

A.2.2 Single Beam Echosounders

No single beam echosounders were utilized for data acquisition.

A.2.3 Side Scan Sonars

A.2.3.1 Klein Marine Systems, Inc. 5000 v2

Manufacturer	Klein Marine Systems, Inc.
Model	5000 v2

<table>
<tr><td>Description</td><td>The Klein High Speed, High Resolution Multi-Beam Side Scan Sonar (SSS) system is a beam-forming acoustic imagery device. The integrated system includes a Klein 5000 towfish, a Transceiver/Processing Unit (TPU), and a computer for user interface. Stern-towed units also include a tow cable telemetry assembly. The towfish operates at a frequency of 455kHz and a vertical beam angle of 40°, and can resolve up to 5 discrete received beams per transducer stave. The system is capable of ranges up to 250 meters. In addition, the Klein 5000 V2 model can collect bathymetric information using phase differencing. Each side scan transducer stave contains 3 bathymetry staves. The bathymetry staves operate at 455kHz, with an along track resolution of 0.4°, and can resolve one discrete beam per side. The Klein 5000 is deployed as a stern-towed unit.

Positioning of the towfish is calculated using Caris HIPS and is derived from the amount of cable out, the towfish depth (from the towfish pressure gauge), the vessel's Course Made Good (CMG), and the vessel's heading. Towfish altitude is maintained between 8% and 20% of the range scale unless specifically noted in the Descriptive Report. Vessel speed is adjusted during SSS acquisition to ensure that object detection density is met. Confidence checks are performed by noting changes in linear bottom features extending to the outer edges of the digital side scan image, and by verifying aids to navigation or other known features on the side scan record.</td></tr>
<tr><td>Inventory</td><td><table><tr><td>S222</td><td><table>
<tr><td>Component</td><td>TPU</td><td>Towfish</td></tr>
<tr><td>Model Number</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Serial Number</td><td>778</td><td>385</td></tr>
<tr><td>Frequency</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Calibration</td><td>2017-07-01</td><td>2017-07-01</td></tr>
<tr><td>Accuracy Check</td><td>2017-07-01</td><td>2017-07-01</td></tr>
</table></td></tr></table></td></tr>
</table>

A.2.3.2 Klein Marine Systems, Inc. 5000

<table>
<tr><td>Manufacturer</td><td>Klein Marine Systems, Inc.</td></tr>
<tr><td>Model</td><td>5000</td></tr>
<tr><td>Description</td><td>The Klein 5000 system used on THOMAS JEFFERSON is an older version of the 5000 v2 system. The specifications of the 5000 system are identical to the 5000 v2 system in all substantial aspects relating to system performance. The 5000 systems are smaller than the 5000 v2 system and are deployed on the HSLs in a hull-mounted configuration.</td></tr>
<tr><td>Inventory</td><td><table><tr><td>2903</td><td><table>
<tr><td>Component</td><td>TPU</td><td>Towfish</td></tr>
<tr><td>Model Number</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Serial Number</td><td>009</td><td>319</td></tr>
<tr><td>Frequency</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Calibration</td><td>2017-07-01</td><td>2017-07-01</td></tr>
<tr><td>Accuracy Check</td><td>2017-07-01</td><td>2017-07-01</td></tr>
</table></td></tr></table></td></tr>
</table>

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.

A.3 Manual Sounding Equipment

A.3.1 Diver Depth Gauges

No diver depth gauges were utilized for data acquisition.

A.3.2 Lead Lines

No lead lines were utilized for data acquisition.

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 Horizontal and Vertical Control Equipment

A.4.1 Base Station Equipment

No base station equipment was utilized for data acquisition.

A.4.2 Rover Equipment

No rover equipment was utilized for data acquisition.

A.4.3 Water Level Gauges

No water level gauges were utilized for data acquisition.

A.4.4 Levels

No levels were utilized for data acquisition.

A.4.5 Other Horizontal and Vertical Control Equipment

No other equipment were utilized for data acquisition.

A.5 Positioning and Attitude Equipment

A.5.1 Positioning and Attitude Systems

A.5.1.1 Applanix Corporation POS MV 320 Version 5

Manufacturer	Applanix Corporation
Model	POS MV 320 Version 5

<table>
<tr><td>Description</td><td>The Applanix POS MV 320 Version 5 (Position and Orientation System for Marine Vessels, hereafter ‘POS MV v5’) is a GNSS Inertial Navigation System that provides high frequency and highly accurate vessel trajectory (both navigation/position and attitude/ orientation) data. The system incorporates data from an Inertial Motion Unit (IMU) and dual multi-constellation GNSS receivers. Advanced proprietary Kalman Filtering techniques are used to provide a blended navigation and trajectory solution in real-time that is both highly accurate and reliable. The POS MV v5 also computes vessel heave (both instantaneous and ‘delayed’ heave values). The POS MV v5 system is integrated with all platform acquisition systems. Data from the POS MV v5 is applied to echosounder data in real-time and logged for post-processing/archiving.

The POS/ MV generates attitude data in three axes (roll, pitch, and heading) to an accuracy of 0.02° or better. Real-time heave measurements supplied by the POS/MV maintain an accuracy of 5% of the measured vertical displacement or 05 cm (whichever is greater) for vertical motions less than 20 seconds in period. The standard practice on THOMAS JEFFERSON is to configure the Heave Bandwidth filter with a damping coefficient of 0.707. The standard practice is to apply a high pass filter that is determined by the longest swell period encountered on the survey grounds. The POS MV v5 is also calculates a ‘delayed heave’ (Applanix labels this ‘TrueHeave’) value. The Applanix delayed heave algorithm uses a delayed filtering technique to eliminate many of the artifacts present in real time heave data. Applanix delayed heave measurements maintain an accuracy of 2% of the measured vertical displacement or 02 cm (whichever is greater) for vertical motions less than 20 seconds in period. Delayed heave measurements are logged and applied to MBES data in post processing.

A graphical user interface provides visual representations and summary statistics of data quality in real-time. Performance parameters are monitored by acquisition hydrographers in real-time and checked against HSSD requirements.

Position and trajectory data from the POS MV v5 system is applied in both real-time and post-processed applications. Navigation and attitude data is applied to all echosounder data in real-time. Raw data from the POS MV v5 can also be post-processed after acquisition to achieve trajectory solutions that are more accurate than those achieved in real-time by using forward/backward processing methods. Post-processing is conducted using the Applanix POSPac MMS software suite. Post-processing methodology is described elsewhere in this document.</td></tr>
<tr><td>Inventory</td><td><table><tr><td rowspan="4">S222</td><td>Component</td><td>IMU</td><td>PCS</td></tr><tr><td>Model Number</td><td>N/A</td><td>N/A</td></tr><tr><td>Serial Number</td><td>1047</td><td>6497</td></tr><tr><td>Calibration</td><td>2017-07-01</td><td>2017-07-01</td></tr></table></td></tr>
</table>

A.5.1.2 Applanix Corporation POS MV 320 Version 4

Manufacturer	Applanix Corporation

<table>
<tr><td>Model</td><td colspan="2">POS MV 320 Version 4</td></tr>
<tr><td>Description</td><td colspan="2">HSL 2903 and HSL 2904 are equipped with Applanix POS MV 320 Version 4 systems. The specifications of the Version 4 system are identical to the Version 5 systems described elsewhere in the document in all substantial aspects relating to system performance.</td></tr>
<tr><td>Inventory</td><td>2903</td><td>
<table>
<tr><td>Component</td><td>IUM</td><td>PCS</td></tr>
<tr><td>Model Number</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Serial Number</td><td>131</td><td>3245</td></tr>
<tr><td>Calibration</td><td>2017-07-01</td><td>2017-07-01</td></tr>
</table>
</td></tr>
</table>

A.5.2 DGPS

DGPS equipment was not utilized for data acquisition.

A.5.3 GPS

GPS equipment was not utilized for data acquisition.

A.5.4 Laser Rangefinders

Laser rangefinders were not utilized for data acquisition.

A.5.5 Other Positioning and Attitude Equipment

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

A.6 Sound Speed Equipment

A.6.1 Moving Vessel Profilers

A.6.1.1 AML Oceanographic AML Micro CTD

Manufacturer	AML Oceanographic
Model	AML Micro CTD

Description	The Micro CTD is a sensor package used to measure conductivity and temperature in the water column. The Micro CTD is attached to the Moving Vessel Profiler towfish on S222.
Inventory	*S222* — *Component*: Micro CTD; *Model Number*: N/A; *Serial Number*: 007761; *Calibration*: 2017-07-01

A.6.1.2 AML Oceanographic AML Smart/Micro SV&P Probe

Manufacturer	AML Oceanographic
Model	AML Smart/Micro SV&P Probe
Description	An AML Micro SV&P Probe is used with the MVP system on S222 to collect speed of sound profiles. The speed of sound is measured directly using a 'time-of-flight' sensor. Depth is calculated via strain gauge pressure.
Inventory	*S222* — *Component*: Micro SV&P; *Model Number*: N/A; *Serial Number*: 007761; *Calibration*: 2017-07-01

A.6.2 CTD Profilers

A.6.2.1 Sea-bird Electronics SBE 19plus

Manufacturer	Sea-bird Electronics
Model	SBE 19plus
Description	Sea-Bird Electronics SBE 19plus SeaCAT Conductivity, Temperature, and Depth (CTD) Profilers are used on HSL 2903 and HSL 2904 to collect vertical sound speed profiles. The speed of sound is calculated from temperature, salinity, and pressure measurements. Temperature is measured directly. Salinity is calculated from measured electrical conductivity. Depth is calculated via strain gauge pressure. The system is configured for a sampling rate of 0.5 seconds. CTD equipment is deployed manually aboard TJ launches.
Inventory	*Component*: CTD; *Model Number*: N/A; *Serial Number*: 19P33589-4487; *Calibration*: 2017-07-01

A.6.3 Sound Speed Sensors

A.6.3.1 Teledyne Reson (formally RESON A/S) Reson SVP-71

<table>
<tr><td>Manufacturer</td><td colspan="3">Teledyne Reson (formally RESON A/S)</td></tr>
<tr><td>Model</td><td colspan="3">Reson SVP-71</td></tr>
<tr><td>Description</td><td colspan="3">Reson SVP-71 are sensors to collect the speed of sound at the face of the Reson 7125-SV2 transducers on HSL 2903 and HSL 2904. The sensors are bolted to the mounting sleds near the face of the transducer on each launch. The speed of sound is measured directly using a direct path echosounding sensor. The SVP-71 is integrated with the Reson 7125-SV2 TPU.</td></tr>
<tr><td rowspan="4">Inventory</td><td rowspan="4">2903</td><td>Component</td><td>CTD</td></tr>
<tr><td>Model Number</td><td>N/A</td></tr>
<tr><td>Serial Number</td><td>19P33589-4487</td></tr>
<tr><td>Calibration</td><td>2017-07-01</td></tr>
</table>

A.6.4 TSG Sensors

No surface sound speed sensors were utilized for data acquisition.

A.6.5 Other Sound Speed Equipment

No surface sound speed sensors were utilized for data acquisition.

A.7 Computer Software

A.7.1 Caris HIPS

Manufacturer	Caris
Software Name	HIPS
Version	10.3
Installation Date	2017-07-01
Use	Processing

A.7.2 Caris BASE Editor

Manufacturer	Caris
Software Name	BASE Editor
Version	4.3
Installation Date	2017-07-01
Use	Processing

A.7.3 NOAA Pydro

Manufacturer	NOAA
Software Name	Pydro
Version	17
Installation Date	2017-07-01
Use	Acquisition and Processing

A.7.4 HYPACK - A Xylem Brand HYPACK

Manufacturer	HYPACK - A Xylem Brand
Software Name	HYPACK
Version	2017
Installation Date	2017-07-01
Use	Acquisition

A.7.5 Applanix Corporation POSPac MMS

Manufacturer	Applanix Corporation
Software Name	POSPac MMS
Version	8.2
Installation Date	2017-07-01
Use	Processing

A.7.6 Applanix Corporation POSView

Manufacturer	Applanix Corporation
Software Name	POSView

Version	8.32
Installation Date	2017-07-01
Use	Acquisition

A.7.7 QPS, Inc Fledermaus

Manufacturer	QPS, Inc
Software Name	Fledermaus
Version	7.4.0d
Installation Date	2017-07-01
Use	Processing

A.7.8 ESRI, Inc. ArcGIS

Manufacturer	ESRI, Inc.
Software Name	ArcGIS
Version	10.3
Installation Date	2017-07-01
Use	Acquisition and Processing

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

No bottom sampling equipment was utilized for data acquisition.

B System Alignment and Accuracy

B.1 Vessel Offsets and Layback

B.1.1 Vessel Offsets

All offsets for S222 are derived from full surveys performed by Kongsberg USA-contracted personnel and have been verified by Hydrographic Systems and Technology Branch (HSTB) personnel. All offsets are tracked and updated as needed. Offsets values are known in the vessel reference frame, the IMU reference frame, and Kongsberg EM710 reference frame. Offset values for the Kongsberg MBES systems are entered into SIS and the ship's Caris HIPS Hydrographic Vessel File (HVF), with the exception of the orthogonal offsets between the primary Applanix GNSS sensor antenna and the Applanix IMU. The offset between the primary GNSS antenna and the IMU is applied to the POS MV. The POS MV provides navigation and attitude data in the IMU reference frame at the IMU reference point. All other offsets are applied to data during the SVP or Merge processing steps in CARIS HIPS.

Offsets are applied to side scan sonar data during the Compute Towfish Navigation step.

All offsets for HSL 2903 and HSL 2904 are derived from full vessel surveys performed by NGS personnel. The reference point for the launches is the IMU.

All offsets, correctors, and values used in TPU calculation that are stored in the HVF file can be found in the Appendices to this report. HVF Reports are output from the Caris HVF Editor in a plain text document readable anywhere and include all of the requested values for the DAPR necessary to reproduce an HVF.

B.1.1.1 Vessel Offset Correctors

<table>
<tr><td>Vessel</td><td colspan="4">See included HVFs for information on applied correctors.</td></tr>
<tr><td>Echosounder</td><td colspan="4">See included HVFs for information on applied correctors. See included HVFs for information on applied correctors.</td></tr>
<tr><td>Date</td><td colspan="4">2017-01-01</td></tr>
<tr><td rowspan="14">Offsets</td><td rowspan="7">MRU to Transducer</td><td></td><td>Measurement</td><td>Uncertainty</td></tr>
<tr><td>x</td><td>0.000 meters</td><td>0.000 meters</td></tr>
<tr><td>y</td><td>0.000 meters</td><td>0.000 meters</td></tr>
<tr><td>z</td><td>0.000 meters</td><td>0.000 meters</td></tr>
<tr><td>x2</td><td>0.000 meters</td><td>0.000 meters</td></tr>
<tr><td>y2</td><td>0.000 meters</td><td>0.000 meters</td></tr>
<tr><td>z2</td><td>0.000 meters</td><td>0.000 meters</td></tr>
<tr><td rowspan="6">Nav to Transducer</td><td>x</td><td>0.000 meters</td><td>0.000 meters</td></tr>
<tr><td>y</td><td>0.000 meters</td><td>0.000 meters</td></tr>
<tr><td>z</td><td>0.000 meters</td><td>0.000 meters</td></tr>
<tr><td>x2</td><td>0.000 meters</td><td>0.000 meters</td></tr>
<tr><td>y2</td><td>0.000 meters</td><td>0.000 meters</td></tr>
<tr><td>z2</td><td>0.000 meters</td><td>0.000 meters</td></tr>
<tr><td>Transducer Roll</td><td>Roll</td><td>0.00 degrees</td><td></td></tr>
</table>

B.1.2 Layback

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

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

Layback correctors were not applied.

B.2 Static and Dynamic Draft

B.2.1 Static Draft

Static draft is measured on the S222 using a Sutron Bubbler system. The orifice was surveyed into the IMU reference frame and a waterline height was calculated. A common waterline for the ship when fully loaded with fuel and ballasted normally is approximately 35cm below the reference point of the ship, but the waterline may change by as much as +/- 30cm over the course of a field season.

The Static Draft is not applied to soundings for ERS Surveys.

The waterline for S222 is measured at least weekly. When feasible, waterline measurements are taken before and after fueling or ballasting of the ship. The values are kept in a static draft log and periodically updated in the HVF. Once applied in the HVF, all affected lines have SVP re-applied and are then merged so that the updated waterline measurements will be applied.

The waterline for HSL platforms is measured using physical measurements from the waterline of the vessel to physical known benchmarks.

All offsets, correctors, and values used in TPU calculation that are stored in the HVF file can be found in the included Appendix Folder, HVF Reports. These HVF Reports are output from the Caris HVF Editor in a plain text document readable anywhere, and include all of the requested values for the DAPR necessary to reproduce an HVF.

B.2.1.1 Static Draft Correctors

Vessel		See included HVFs for information on applied correctors.
Date		2017-01-01
Loading		0 meters
Static Draft	*Measurement*	0 meters
	Uncertainty	0 meters

B.2.2 Dynamic Draft

Dynamic draft for all platforms was measured using the Post Processed Kinematic GPS method outlined in section 1.4.2.1.2.1 of NOAA's FPM. To reduce the effect of any potential current, reciprocal lines were run at each RPM step in order to get an average speed over ground for each RPM. This average speed was used to estimate the vessel's speed through the water. Dynamic draft and vessel offsets corrector values are stored in the HIPS Vessel Files (HVF).

In ERS surveys (those that use recorded GPS heights corrected via a VDatum SEP model to achieve tidal datum) the dynamic draft correction is not applied to the soundings.

All offsets, correctors, and values used in TPU calculation that are stored in the HVF file can be found in the included Appendix Folder, HVF Reports. These HVF Reports are output from the Caris HVF Editor in a plain text document readable anywhere, and include all of the requested values for the DAPR necessary to reproduce an HVF.

B.2.2.1 Dynamic Draft Correctors

Vessel	See included HVFs for information on applied correctors.	
Date	2017-01-01	
Dynamic Draft	*Speed (m/s)*	*Draft (m)*
	0.00	0.00
Uncertainty	*Vessel Speed (m/s)*	*Delta Draft (m)*
	0.00	0.00

B.3 System Alignment

B.3.1 System Alignment Methods and Procedures

THOMAS JEFFERSON conducts MBES calibration tests during annual HSRR activities for each individual multibeam system on the ship and her launches.

Multibeam systems with two frequencies required an individual test for each frequency. The procedure used follows that outlined in section 1.5.5.1 of the Field Procedures Manual dated April 2014. Timing bias was determined using the method of running the same line at different speeds. Pitch and yaw bias was determined using a target on the seafloor. Finally, roll bias was determined using the standard flat bottom method. Offset values for all platforms were derived using Caris' patch testing tools during annual HSRR activities.

All calibration reports can be found in the Appendix Folder.

B.3.1.1 System Alignment Correctors

<table>
<tr><td>Vessel</td><td>See included HVFs and calibration reports for information on applied correctors.</td></tr>
<tr><td>Echosounder</td><td>See included HVFs and calibration reports for information on applied correctors. See included HVFs and calibration reports for information on applied correctors.</td></tr>
<tr><td>Date</td><td>2017-01-01</td></tr>
<tr><td>Patch Test Values</td><td>
<table>
<tr><td></td><td>Corrector</td><td>Uncertainty</td></tr>
<tr><td>Transducer Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Navigation Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Pitch</td><td>0.00 degrees</td><td>0.00 degrees</td></tr>
<tr><td>Roll</td><td>0.00 degrees</td><td>0.00 degrees</td></tr>
<tr><td>Yaw</td><td>0.00 degrees</td><td>0.00 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
</table>
</td></tr>
</table>

C Data Acquisition and Processing

C.1 Bathymetry

C.1.1 Multibeam Echosounder

Data Acquisition Methods and Procedures

All multibeam data on THOMAS JEFFERSON is logged using Kongsberg Seafloor Information System (SIS) in the .all file format.

During acquisition aboard THOMAS JEFFERSON, the hydrographer:

- Monitors the SIS interface for errors and data quality

- Monitors the SIS interface for indication of sound speed changes requiring a cast, and conducts casts as necessary

- Monitors the Hysweep interface in HYPACK

- Monitors the vessel speed and requests the bridge to adjust as necessary to ensure density and coverage specifications are met

All MBES data on the launches is logged using HYPACK in the .HSX file format.

During acquisition aboard the launches, the hydrographer:

- Monitors the Reson 7k control interface on the Reson MBES TPU for errors and data quality

- Monitors the Hysweep interface in HYPACK

- Monitors the vessel speed and requests the coxswain to adjust as necessary to ensure density and coverage specifications are met

Data Processing Methods and Procedures

Five workflows exist depending on whether a survey uses zoned tides, TCARI tides, Marinestar service and the Real-Time Precise Point Positioning (RT3P) method, the Post-Processed Precise Point Positioning (5P) method, or Inertially Aided Post Processed Kinematic (IAPPK) method. A more detailed description of 5P and IAPPK workflows is provided elsewhere.

These workflows are shown in descending order of preferred use.

RT3P:

1) Convert .all file into Caris project
2) Load Delayed Heave via Auxiliary Data Import
3) Sound Velocity Correction (note: no file is loaded in this step. This is purely to apply Delayed Heave.)
4) Compute GPS Tide
5) Merge
6) Compute Total Propagated Uncertainty (TPU) using fixed uncertainty values (11cm for Marinestar, and the uncertainty value provided as part of the vDatum model)

5P:

1) Create SBET and RMS files in POSPac MMS.
2) Convert raw .HSX data to Caris HDCS format
3) Load Delayed Heave
4) Import ancillary data: SBET and RMS
5) Apply tide correctors. While unused, if available these are useful for a QC check in Subset Editor.
6) Compute GPS Tides using the provided VDatum SEP model.
7) Apply sound speed correctors
8) Merge; use GPS Tides.
9) Compute Total Propagated Uncertainty (TPU)

IAPPK:

IAPPK requires a delay of around 48 hours to produce the SBET and RMS files, due to reliance on updates of CORS station and ephemeris data. The need for fast QC of the data ("night processing") to allow planning of the next day's survey operations necessitates that initial processing must happen before the IAPPK solution is available. As a result, it initially follows the tidal scheme appropriate to that project area (Zoned Tides or TCARI). Once sufficient time has passed, SBETs and RMS files are produced and the data is reprocessed using the same workflow as 5P, skipping the conversion and Delayed Heave steps.

Zoned Tides:

1) Convert raw .HSX data to Caris HDCS format
2) Load Delayed Heave
3) Apply tide correctors
4) Apply sound speed correctors
5) Merge
6) Compute

TCARI Tides:

The TCARI Tides work flow is the same as Zoned Tides except that Step 3 applies the TCARI correctors via Pydro, and Step 6 applies "realtime" tidal uncertainty values instead of project specific static values.

At this stage, all of the work flows merge into a common process:

1) Create CUBE surfaces. Surface resolution is dictated by the type of coverage required (Complete Coverage vs. Object Detection), and the depth of water. Disambiguation method is NOAA CUBE Parameters. Compliance with HSSD gridding requirements is strictly observed.
2) Review the CUBE surface for holidays.
3) Create a holiday line plan.
4) Review the uncertainty and standard deviation layers and address areas where the standards set by the HSSD are exceeded.
5) Examine all surfaces for erroneous surface designation and evidence of systematic errors. Also identify features and look for evidence of shoaling.

6) Significant features are flagged 'designated', forcing the CUBE algorithm to honor the depth of the sounding. Designated soundings are reviewed to ensure compliance with guidance in the HSSD.
7) Create finalized grids. In finalization, the standard deviation for each node in the surface is multiplied by 1.96 to provide the 95% (2-sigma) confidence level. Standard deviation is then compared to the computed Total Vertical Uncertainty (TVU) for each node. The larger of the two values is retained as the finalized Uncertainty for each node. Finalization is also when the surface is forced to honor designated soundings.

C.1.2 Single Beam Echosounder

Single beam echosounder bathymetry was not acquired.

C.1.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar bathymetry was not acquired.

C.1.4 Gridding and Surface Generation

C.1.4.1 Surface Generation Overview

After initial processing the bathymetric data is gridded into BASE surfaces using the CUBE algorithm. This type of surface calculates a horizontal and vertical uncertainty for each sounding, derived from the combined uncertainty from each of the sensors that contributes data to the sounding (e.g water levels, tide zoning, attitude sensor error, navigation sensor horizontal position error, and sound velocity profile error). Individual soundings are then propagated to grid nodes, which takes on a depth value as well as an uncertainty value based on all the soundings that contribute to the node. The influence of a sounding on a grid node is limited to 0.707 times the grid resolution.

C.1.4.2 Depth Derivation

Filters are used on a case-by-case basis as determined by the hydrographer. Refer to the Descriptive Report for more information. Gridding parameters and surface computation algorithms comply with the HSSD and are described above.

C.1.4.3 Surface Computation Algorithm

MBES data is gridded using the CUBE algorithm. Resolution is dictated by the Project Instructions, as well as section 5.2.2 of the HSSD. The disambiguation method used is always Density and Local. The settings used for Capture Distance Scale, Horizontal Error Scale, and Capture Distance Minimum are those listed in section 4.2.1.1.1.1 of the FPM. After creation, Uncertainty and CUBE surfaces go through a quality control process. During this process, the Depth, Uncertainty, Standard Deviation, and Density child layers are examined for compliance with NOAA specifications. After the surfaces pass quality control, they are finalized. Uncertainty values for finalized surface come from the greater of either Uncertainty, or Standard Deviation.

C.2 Imagery

C.2.1 Multibeam Backscatter Data

Data Acquisition Methods and Procedures

All backscatter data on THOMAS JEFFERSON are logged in the SIS .all format.

All backscatter data on the launches are logged in the Reson .s7k file format.

Data Processing Methods and Procedures

All acquired backscatter data are processed into a mosaic and delivered to AHB. All processing of backscatter is done using the FMGT module of the QPS Fledermaus software package in accordance with OCS standard data processing methods.

C.2.2 Side Scan Sonar

Data Acquisition Methods and Procedures

All side scan sonar data are logged using Klein SonarPro, in the .SDF format. During acquisition the hydrographer:

- Monitors range, towfish height, heading, pitch, roll, latitude, longitude, speed, pressure, and temperature;

- Adjusts towfish height (for operations aboard THOMAS JEFFERSON)

Data Processing Methods and Procedures

1) Convert raw .sdf data using Caris SIPS;
2) Scan Navigation and Attitude data, flagging erroneous data as rejected;
3) Re-compute towfish navigation. This is when tow point offsets and horizontal layback is applied to the data;
4) A primary reviewer scans each line for significant contacts;
5) A secondary reviewer makes an independent check-scan of all lines, verifying contacts and checking for missed contacts;
6) If the Project Instructions call for 200% Side Scan coverage, the scanners check correlation of contacts between 100% and 200% coverage;
7) Correlation is also used to reveal systematic errors, particularly if a contact shows up on lines collected in opposite or orthogonal directions;
8) Create individual mosaics for 100% and 200% coverage. Examine for coverage;
9) If necessary, create a holiday line plan.

C.2.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar imagery was not acquired.

C.3 Horizontal and Vertical Control

C.3.1 Horizontal Control

C.3.1.1 GNSS Base Station Data

GNSS base station data was not acquired.

C.3.1.2 DGPS Data

DGPS data was not acquired.

C.3.2 Vertical Control

C.3.2.1 Water Level Data

Data Acquisition Methods and Procedures

THOMAS JEFFERSON uses 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.

In the event of issues with the real-time solution, the POS files produced during acquisition can be processed through the POSPac MMS software to produce a trajectory solution in the WGS84 reference frame and an associated uncertainty file containing the realtime uncertainty estimates of the position and attitude data.

THOMAS JEFFERSON does not normally install GNSS reference stations or temporary tide stations for operations on the East Coast. Data from permanently installed GNSS reference stations and/or tide stations (typically maintained by NGS and CO-OPS, respectively) may be used in certain workflows (described below).

Data Processing Methods and Procedures

Vertical control requirements for surveys conducted during the 2017 field season by THOMAS JEFFERSON are satisfied through the use of one or more of the following methods.

Discrete Zoned Tides:

This method utilizes one or more National Water Level Observation Network (NWLON) water level gauges and a discrete zoned tidal modal to determine vertical control correctors to be applied to soundings at a given location and time. Co-range and co-phase measurements from the NWLON stations are used to break the project area into zones, each of which has a distinct time-of-tide and range-of-tide corrector. CO-OPS provides the field unit with a Caris compatible file which takes observed water levels from surrounding gauges, computes the time and range correctors for each zone, and uses the zoned data to reduce bathymetric soundings to MLLW. THOMAS JEFFERSON does not install tertiary gauges in support of tidal modeling. After completion of a survey area, CO-OPS verifies all zoning and water level data.

TCARI Tides:

Tidal Constituent and Residual Interpretor is an alternative to discrete zoning. A TCARI grid is a triangulated network that uses two or more water level gauges to create a weighted network across the survey area. Each point on the grid has a discrete tidal interpolation that is based on the horizontal nearness of a water level gauge, the harmonic constants of the area, and the residual water levels. Bathymetric data is then reduced to MLLW using the TCARI tool in Pydro. Like zoned tides, CO-OPS verifies TCARI grids and observed water levels at the conclusion of each survey.

GPS Tides:

Trajectory solutions and VDatum separation models that meet OCS ERS specifications can also be used to provide vertical control. Using this method the bathymetric data is initially referenced to the ellipsoid using the high accuracy position data. It is later reduced to MLLW using a separation model called VDatum, which is provided to the field unit by NOAA's Hydrographic Services Division.

Methods employed to meet Ellipsoidally Referenced Survey (ERS) specifications include the methods described below:

Vertical control requirements for ellipsoidally referenced surveys conducted during the 2017 field season by THOMAS JEFFERSON are satisfied through the use of one or more of the following methods.

Real-time Precise Point Positioning (RT3P):

THOMAS JEFFERSON uses the Fugro Marinestar satellite based corrector service to provide real-time 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 data are then put out in real time to the EM2040, and positional and motion data are applied to the acquired bathymetry.

In the event of issues with the real-time solution, the POS files produced during acquisition can be 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.

Real-time corrected ellipsoid height is recorded directly in Kongsberg MBES data logged through the Kongsberg SIS program on THOMAS JEFFERSON and is used when processing ship MBES data in CARIS HIPS.

Post-processed Precise Point Positioning (5P):

Raw GNSS-INS observables and Marinestar corrector data logged through POSView can be post-processed in POSPac MMS to provide a trajectory solution that can be applied to MBES data in CARIS HIPS. The 5P is the standard practice for HSL 2903 and HSL 2904. The 5P method is only used on S222 data if required.

Inertially Aided Post-Processed Kinematic:

During post-processing horizontal positioning can be shifted to an Inertially Aided Post-Processed Kinematic (IAPPK) solution. The solution is created by combining GPS/GNSS satellite ephemeris and clock data with position information downloaded from a network of Continually Operating Reference Stations (CORS). The resulting position data is corrected for the effects of atmospheric interference on the GPS signal. The corrected GPS position is then combined with the vessel's inertial data using the POSPac MMS program to create a Smoothed Best Estimate of Trajectory (SBET). The resulting position can be used to apply higher quality navigation information to the processed data.

C.3.2.2 Optical Level Data

Optical level data was not acquired.

C.4 Vessel Positioning

Data Acquisition Methods and Procedures

As described in Section A.5 of this document.

Data Processing Methods and Procedures

As described in Section C.3 of this document.

C.5 Sound Speed

C.5.1 Sound Speed Profiles

Data Acquisition Methods and Procedures

S222 uses an AML Micro CTD Probe installed inside an MVP free-fall fish to acquire sound speed profiles. Profiles aboard the ship are generally acquired at 30 - 90 minute intervals. Cast frequency is increased when the comparisons show significant variability. Sampling intervals are adjusted to ensure spatial variability or if there is suspicion of sudden changes in the water-column.

HSL 2903 and HSL 2904 both use Sea-Bird SBE 19plus CTDs to collect sound speed profiles. Casts are generally taken at 2-4 hour intervals. Casts are also conducted when changing survey areas or when a change of weather, tide, or current warrant. The launch crew also monitors the real time display of the Reson SVP-70/71 sound velocity probe for significant changes in the surface sound velocity.

Velocipy software is used to interface with SBE 19plus CTD equipment and to process CTD data.

Casts are typically taken in the deepest portions of the project area.

The following procedure is followed when conducting manual CTD casts with the SBE 19plus: The instrument is lowered into the water and submerged just below the water's surface for about 1 minute to allow air to escape the salinity cell. The instrument is lowered at the rate of free fall. The instrument is lowered slowly (in some cases, much less than 1 meter/second) through the first 5-10 meters of water in order to accurately sample the sound speed for areas with lenses of fresh water or other complex sound speed variation near the surface.

The Moving Vessel Profiler (MVP) is an automated winch system that deploys a towfish containing a sound speed sensor. The fish is towed behind the survey vessel in a ready position that is marked by messengers attached to the tow cable. The towfish is typically deployed at a ready depth that is approximately the same depth of the ship MBES transducers. Deployment depth is a function of water depth. The towfish descends at the rate of freefall when deployed. Towfish freefall is automatically stopped once a specified depth limit is met and the drag forces on the fish cause it to rise toward the surface due to the ship's forward motion. The cable slack is then pulled in by the winch to the ready towing position.

Aboard all platforms, the hydrographer processes each cast immediately, then reviews it for erroneous data.

Data Processing Methods and Procedures

Sound Speed Manager (distributed with Pydro) is used to download and process all sound speed data on S222. Sound speed cast data is provided to the Kongsberg SIS acquisition program.

Velocipy is generall used to download and process cast data on the launches.

Processed sound speed data data is applied to the MBES data in CARIS HIPS.

C.5.2 Surface Sound Speed

Data Acquisition Methods and Procedures

THOMAS JEFFERSON uses a Valeport probe to find the speed of sound at the approximate depth of the ship transducers.

HSL 2903 and HSL 2904 use Reson SV-71 probes to acquire sound speed at their respective transducer faces.

Sound speed values are applied in real-time to all MBES systems to provide refraction corrections to flat-faced transducers.

The accuracy of each surface sound speed device is checked against the closest CTD data point after every CTD cast.

Data Processing Methods and Procedures

Surface sound speed data are logged directly into both Kongsberg and Reson MBES raw data files. Surface sound speed data is not typically processed after the time of acquisition.

C.6 Uncertainty

C.6.1 Total Propagated Uncertainty Computation Methods

TPU is calculated in Caris HIPS using the Compute TPU tool. The uncertainty values for each input into the TPU model can come from one of three sources: Real-time, Static, or Vessel. Real-time values are provided from the sensor or processing package (e.g. POSPac RMS values). Static values are those entered manually into the Compute TPU dialog (e.g. tidal zoning uncertainty and sound speed measurement uncertainties). Static values are documented in each Descriptive Report. Vessel values are taken from the HVF if no realtime or static values are available.

Uncertainty values entered into the HVF for the multibeam and positioning systems are derived from manufacturer specifications sheets for each sensor and from values set forth in section 4.2.3.8 and Appendix 4 - Caris HVF Uncertainty Values of the 2014 FPM.

Sound speed static values are derived from the guidance in the FPM.

Tide correction uncertainty values depend on the method of correction: real-time values are used for the TCARI workflow; static values specified in the Project Instructions are used for Zoned Tides or ERS workflows.

Ellipsoid height uncertainty values for ellipsoid measurements derived from the Marinstar service are derived from both manufacturer specifications and empirical observation. Static values are used to account for known discrepancies with the magnitude of the position uncertainty values reported by the POS MV system when utilizing Marinestar correctors.

Ellipsoid height uncertainty values for ellipsoid measurements derived from 5P or IAPPK workflows are applied as real-time values from Applanix RMS files.

Both the Kongsberg and Reson MBES systems provide uncertainty statistics that are recorded in raw MBES files.

All offsets, correctors, and values used in TPU calculation that are stored in the HVF file can be found in the included Appendix Folder, HVF Reports. These HVF Reports are output from the Caris HVF Editor in a plain text document readable anywhere, and include all of the requested values for the DAPR necessary to reproduce an HVF.

See included HVFs for information on vessel uncertainty values.

C.6.2 Uncertainty Components

A Priori UncertaintyA priori uncertainty was not applied.

Real-Time Uncertainty

Vessel	*Description*
S222	As discussed above.
2903	As discussed above.

C.7 Shoreline and Feature Data

Data Acquisition Methods and Procedures

The following workflow is used to develop and verify features:

- Potentially significant features are initially identified and inspected in Caris HIPS (both MBES and SSS contacts).

- A development area polygon or point feature is exported from HIPS; a line plan is created using HIPS or ArcMap if needed.

- Object Detection level MBES data is collected over all MBES and/or SSS contacts, VBES designated soundings, and all possible shoal areas.

Quality of data is controlled through:

- Real time monitoring during acquisition to ensure that all features are covered by near nadir beams.

- Inspection of the CUBE surface's Density, Standard Deviation, and Uncertainty layers.

- All developments are examined for significance. Objects found to be significant are flagged with a designated sounding, and become part of the Final Feature File.

Data Processing Methods and Procedures

Feature verification begins during initial data processing. Both SSS and MBES data is processed following the conclusion of daily acquisition operations or at regular intervals for continuous ship operations. Significant contacts are identified and noted during initial processing. All significant contacts are then developed using a MBES. When conducting Multibeam surveys, or when reviewing MBES developments over side scan sonar contacts, the least depths over navigationally significant features are flagged as 'designated soundings', then imported into Caris BASE Editor or HIPS. Inside BASE Editor, each significant contact is given an S-57 attribution, and the hydrographer recommends charting action. The final deliverable is a Final Feature File (FFF) in .000 format.

C.8 Bottom Sample Data

Bottom sample data was not acquired.

D Data Quality Management

D.1 Bathymetric Data Integrity and Quality Management

D.1.1 Directed Editing

All statistics layers generated by the CARIS CUBE implementation are used (including uncertainty, hypothesis count, hypothesis strength, and standard deviation) to direct data cleaning.

D.1.2 Designated Sounding Selection

In accordance with HSSD 2017.

D.1.3 Holiday Identification

Holidays are identified primarily through the use of two tools: the QC Tools program included with recent version of Pydro and via standard tools included in ArcGIS (primarily to inspect SSS mosaics). All surfaces are also visually inspected.

D.1.4 Uncertainty Assessment

In accordance with HSSD 2017 using methods described above.

D.1.5 Surface Difference Review

D.1.5.1 Crossline to Mainscheme

Difference surfaces are conducted in accordance with HSSD 2017 and as outlined in the DR.

D.1.5.2 Junctions

Difference surfaces are conducted in accordance with HSSD 2017 and as outlined in the DR.

D.1.5.3 Platform to Platform

Difference surfaces are conducted in accordance with HSSD 2017 and as outlined in the DR.

D.2 Imagery data Integrity and Quality Management

D.2.1 Coverage Assessment

Coverage is assessed in accordance with HSSD 2017.

Automated and visual methods are used to inspect surface coverage: ArcGIS tools are used to automatically identify coverage deficiencies; surfaces are inspected against brightly colored backgrounds for visible gaps in coverage.

D.2.2 Contact Selection Methodology

Contacts are selected in accordance with HSSD 2017.

Visual inspection of all SSS data is conducted in CARIS HIPS by multiple scanners (initially processor, check scanner and/or sheet manager).

List of Appendices:

Mandatory Report	***File***
Vessel Wiring Diagram	Vessel_Wiring_Diagram-2903-20170701.pdf
	Vessel_Wiring_Diagram-2904-20170701.pdf
	Vessel_Wiring_Diagram-S222-20170122.pdf
Sound Speed Sensor Calibration	AML_MicroSV%26P_007591.pdf
	AML_SmartSV%26P_004988.pdf
	AML_SmartSV%26P_005340.pdf
	AML_ZZZMicroCTD_007761.pdf
	Cast_Away%20Calibration_Depth_GPS.pdf
	Cast_away_conductivity%20and%20Temp_calibration.pdf
	Cast_away2017_01_17Packing%20reciept.pdf
	ODOM%20Digibar%20Pro.pdf
	Reson_SV71_0710064.pdf
	Reson_SV71_4211065.pdf
	Reson_SV71_4211067.pdf
	SBE%2019%20C0285%2004Feb17.pdf
	SBE%2019%20P0285%2002Feb17.pdf
	SBE%2019%20T0285%2004Feb17.pdf
	SBE%2019plus%20C4487%2009Feb17.pdf
	SBE%2019plus%20P4487%2008Feb17.pdf
	SBE%2019plus%20T4487%2009Feb17.pdf
	SBE%2019plus%20V2%20C6667%2004Feb17.pdf
	SBE%2019plus%20V2%20P6667%2001Feb17.pdf
	SBE%2019plus%20V2%20T6667%2004Feb17.pdf
	SBE%2045%20C0491%2014Feb17.pdf
	SBE%2045%20T0491%2014Feb17.pdf
	SSVS_S222_2017.pdf
	Valeport_33711.pdf
	Valeport_33747.pdf
Vessel Offset	20160901-TJ-Vessel_Survey-S222-IMTEC.pdf
	20170501-TJ-Vessel_Survey-2903-NGS.pdf

Mandatory Report	***File***
	20170501-TJ-Vessel_Survey-2904-NGS.pdf
Position and Attitude Sensor Calibration	POS_MV_Cal_Report_2904_2017.pdf POS_MV_Cal_Report_S222_2017.pdf
Echosounder Confidence Check	2903_7125_200kHz_MBES_Patch_2017.pdf 2903_7125_400kHz_MBES_Patch_2017.pdf 2904_7125_SV2_400kHz_MBES_Patch_2017.pdf 2904_SSS_Certification_75mRS_Edgetech4200.pdf 2904SSS_Certification_75mRS.pdf S222_EM710_MBES_Patch_2017.pdf S222_EM2040_MBES_Patch_2017.pdf SSS_Calibration_REPORT_Savannah%20Aug2017%20recert %2075mRS.pdf SSS_Certification_50mRS.pdf SSS_Certification_75mRS.pdf
Echosounder Acceptance Trial Results	20161020_HSTB_TJ_EM2040_and_EM710_Acceptance.pdf

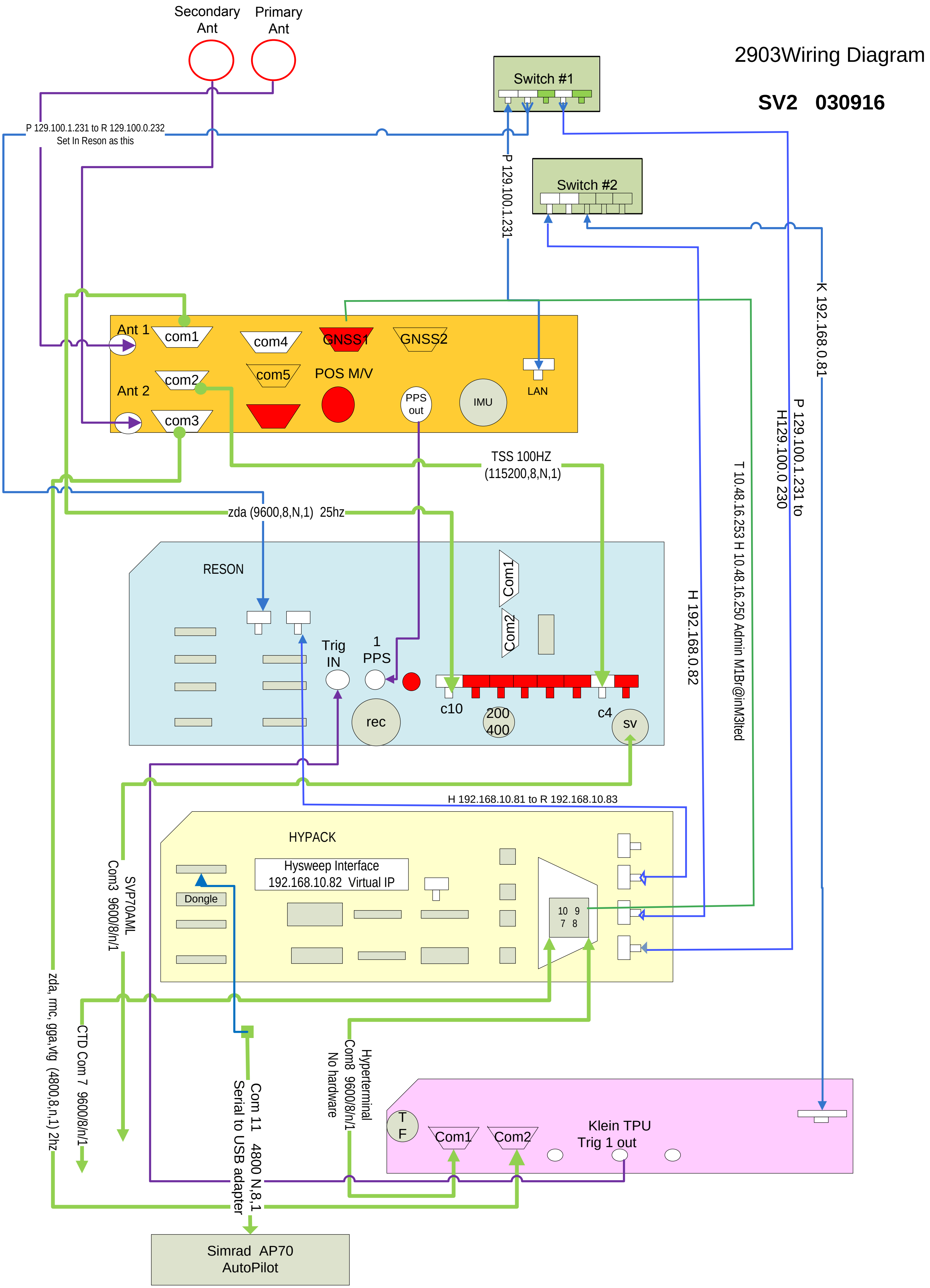
Additional Report	***File***
HVF Values	2903_Reson7125_SV2_400kHz_2017.pdf 2903_SSS_100_2017.pdf 2903_SSS_200_2017.pdf S222_EM2040_2017.pdf TJ_S222_Klein5000_SSS100_2017.pdf TJ_S222_Klein5000_SSS200_2017.pdf
Additional Report	***File***
HSRR Documentation	TJ_2017_Hydrographic_Systems_Readiness_Memo.pdf

E. Approval Sheet

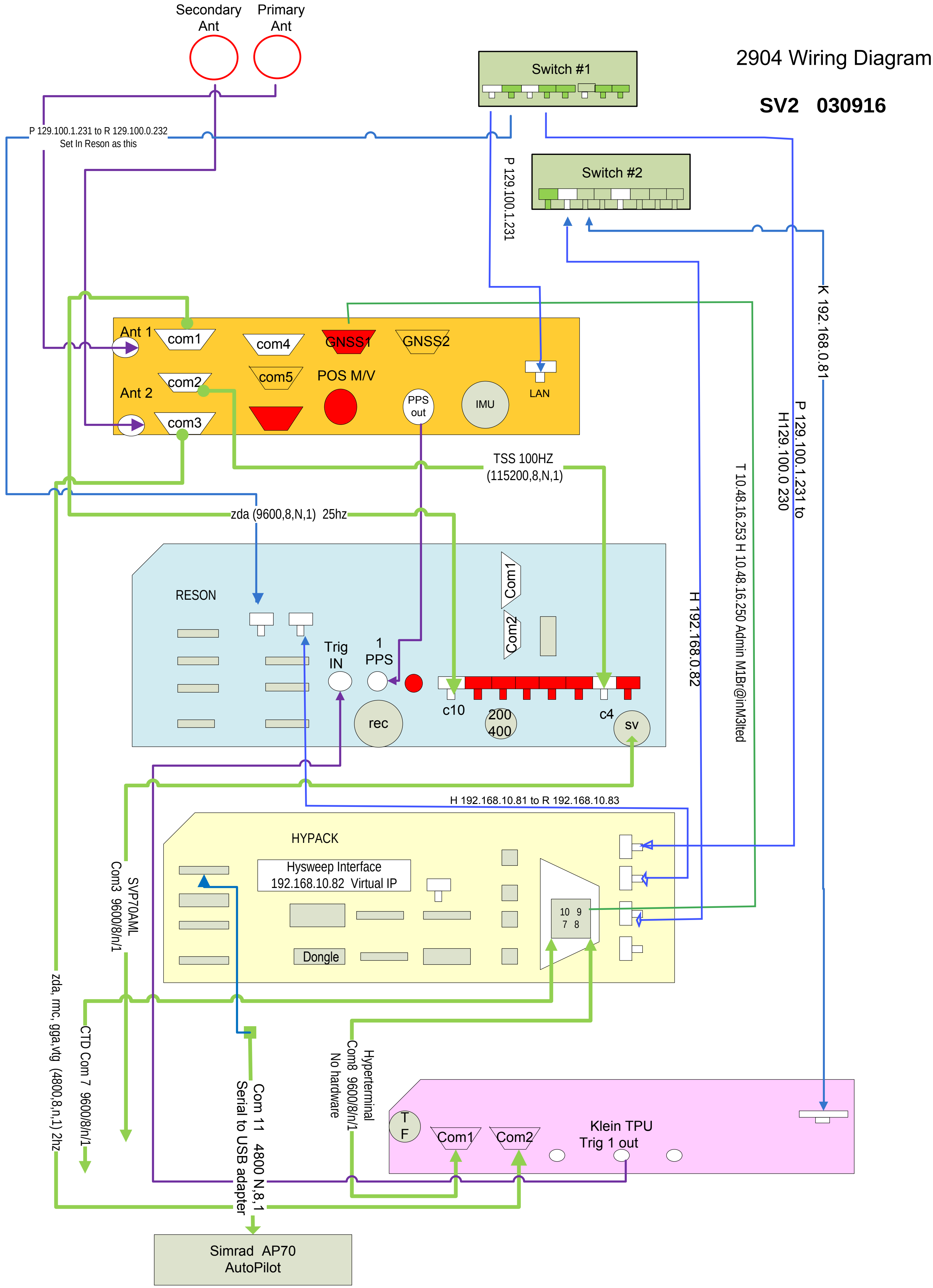
As Chief of Party, I have ensured that standard field surveying and processing procedures were adhered to during these projects in accordance with the Hydrographic Surveys Specifications and Deliverables (2017 ed) and the Field Procedures Manual for Hydrographic Surveying (2014 ed).

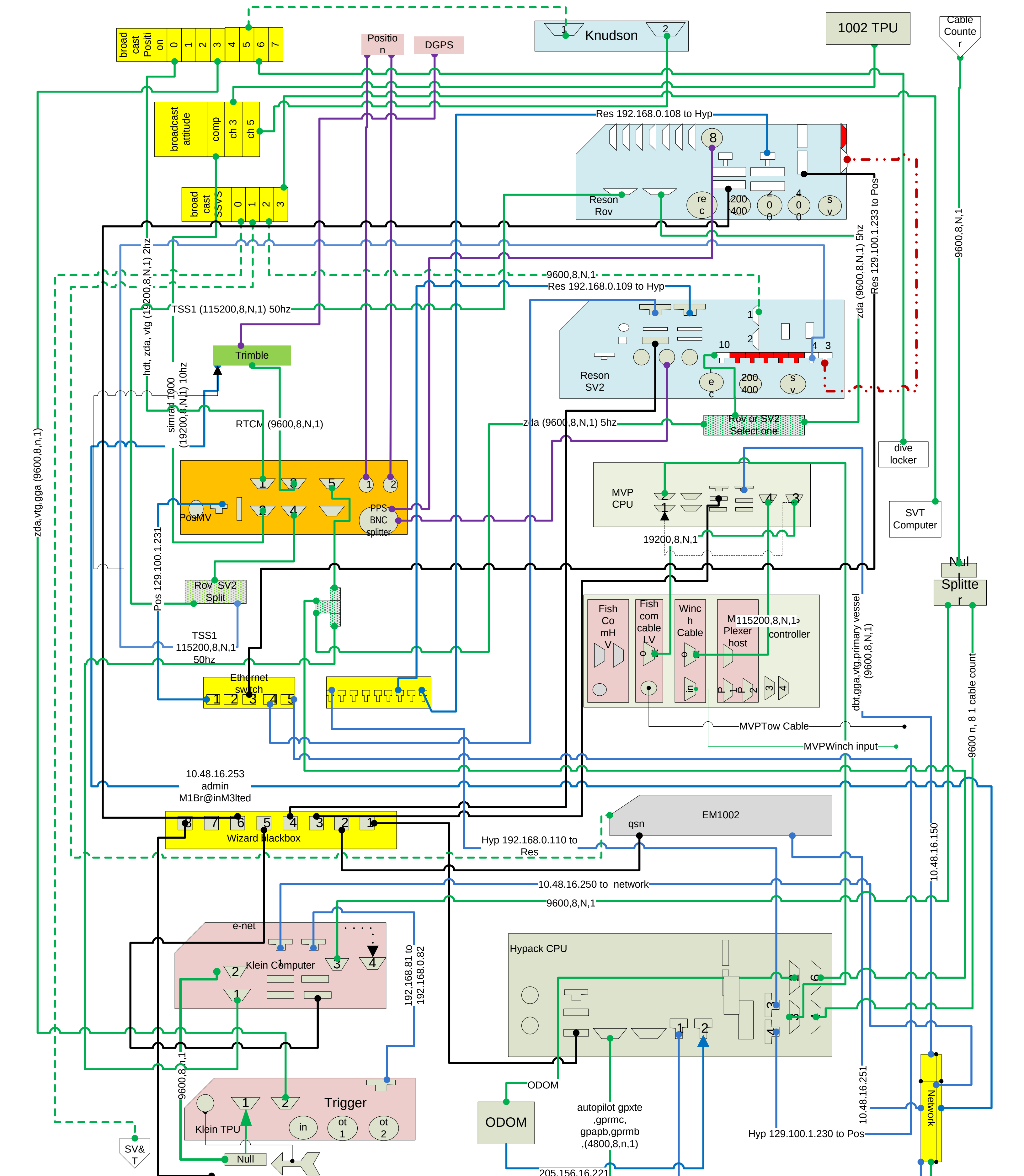
I acknowledge that all of the information contained in this report is complete and accurate to the best of my knowledge.

Approver Name	Approver Title	Date	Signature
LT Anthony Klemm	Field Operations Officer	01/24/2018	
CDR Chris van Westendorp	Commanding Officer	01/24/2018	



2903Wiring Diagram
SV2 030916
Secondary Ant
Primary Ant
Switch #1
Switch #2
P 129.100.1.231 to R 129.100.0.232
Set In Reson as this
P 129.100.1.231
K 192.168.0.81
P 129.100.1.231 to
H129.100.0 230
T 10.48.16.253 H 10.48.16.250 Admin M1Br@inM3lted
H 192.168.0.82
Ant 1
Ant 2
com1
com2
com3
com4
com5
GNSS1
GNSS2
POS M/V
PPS out
IMU
LAN
TSS 100HZ
(115200,8,N,1)
zda (9600,8,N,1) 25hz
RESON
Com1
Com2
Trig IN
1 PPS
rec
c10
200
400
c4
sv
H 192.168.10.81 to R 192.168.10.83
HYPACK
Hysweep Interface
192.168.10.82 Virtual IP
Dongle
10 9
7 8
SVP70AML
Com3 9600/8/n/1
zda, rmc, gga,vtg (4800,8,n,1) 2hz
CTD Com 7 9600/8/n/1
Com 11 4800 N,8,1
Serial to USB adapter
Hyperterminal
Com8 9600/8/n/1
No hardware
T
F
Com1
Com2
Klein TPU
Trig 1 out
Simrad AP70
AutoPilot


2904 Wiring Diagram
SV2 030916
Secondary Ant
Primary Ant
Switch #1
Switch #2
P 129.100.1.231 to R 129.100.0.232
Set In Reson as this
P 129.100.1.231
K 192.168.0.81
P 129.100.1.231 to
H129.100.0 230
T 10.48.16.253 H 10.48.16.250 Admin M1Br@inM3lted
H 192.168.0.82
Ant 1
com1
com4
GNSS1
GNSS2
com2
com5
POS M/V
Ant 2
com3
PPS out
IMU
LAN
TSS 100HZ
(115200,8,N,1)
zda (9600,8,N,1) 25hz
RESON
Com1
Com2
Trig IN
1 PPS
rec
c10
200
400
c4
sv
H 192.168.10.81 to R 192.168.10.83
HYPACK
Hysweep Interface
192.168.10.82 Virtual IP
10 9
7 8
Dongle
SVP70AML
Com3 9600/8/n/1
CTD Com 7 9600/8/n/1
zda, rmc, gga,vtg (4800,8,n,1) 2hz
Com 11 4800 N,8,1
Serial to USB adapter
Hyperterminal
Com8 9600/8/n/1
No hardware
T
F
Com1
Com2
Klein TPU
Trig 1 out
Simrad AP70
AutoPilot



NOTE: PPS input to POS is optional to a BNC switch, usually used one input at a time.

NOTE: Some Ports are FLIP Flopping. Change port at connection and setup when necessary.
Klein Com 3 (Preffered) to 4 and vice versa
MVP Com 3 (Preffered) to 1 and vice versa

Serial to USB or Ethernet combo =dash double dot

POS NETWORK

Pos/MV 129.100.1.231

Hypack 129.100.1.230

SV2 129.100.1.232

ROV 129.100.1.233

RESON Network

Hypack 192.168.0.110

SV2 192.168.0.109

ROV 192.168.0.108

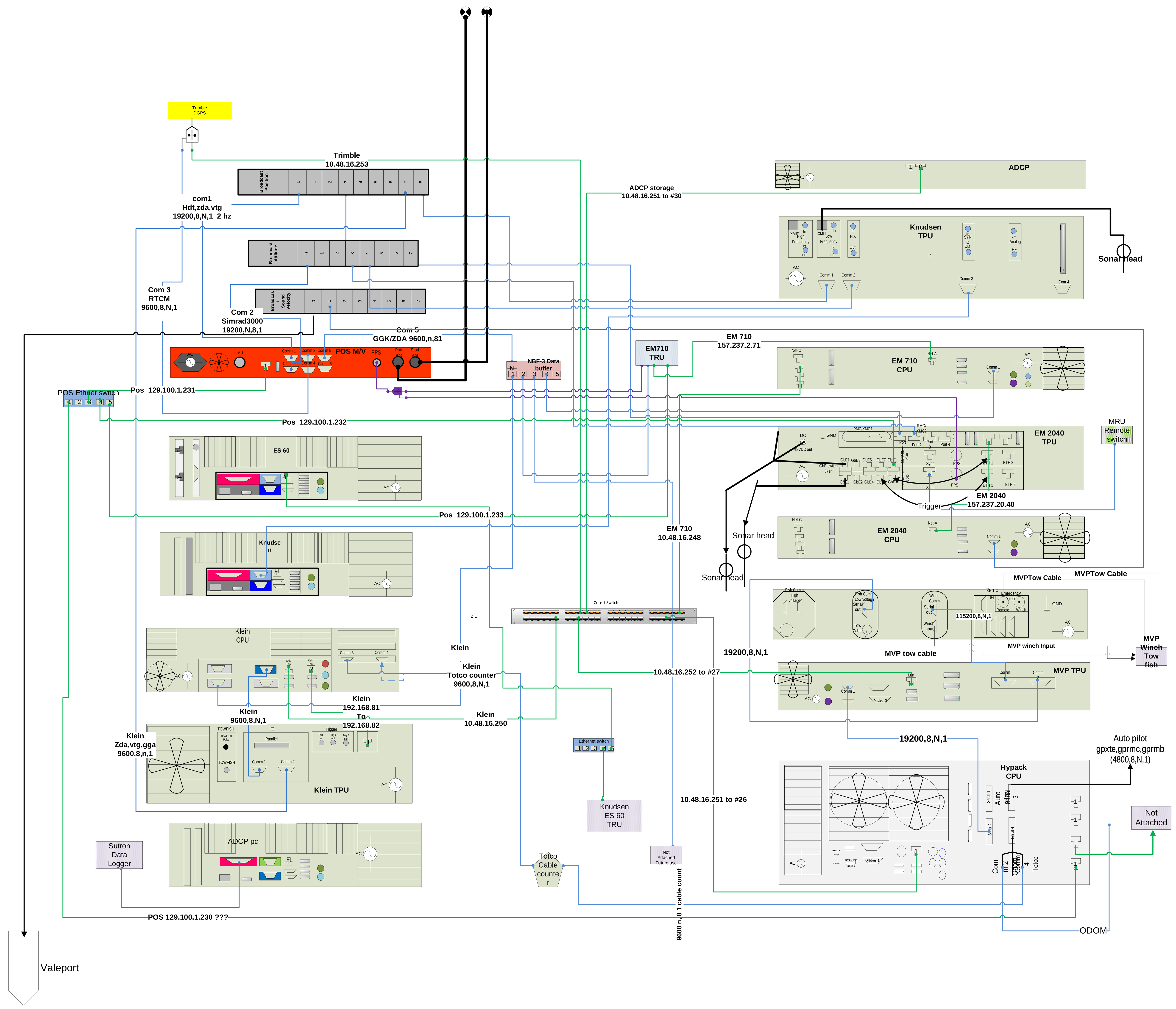
Auto Pilot Com 1 4800 ,N,8,1,n
use ver 10.0.0.9
“Update_4_decimal” name

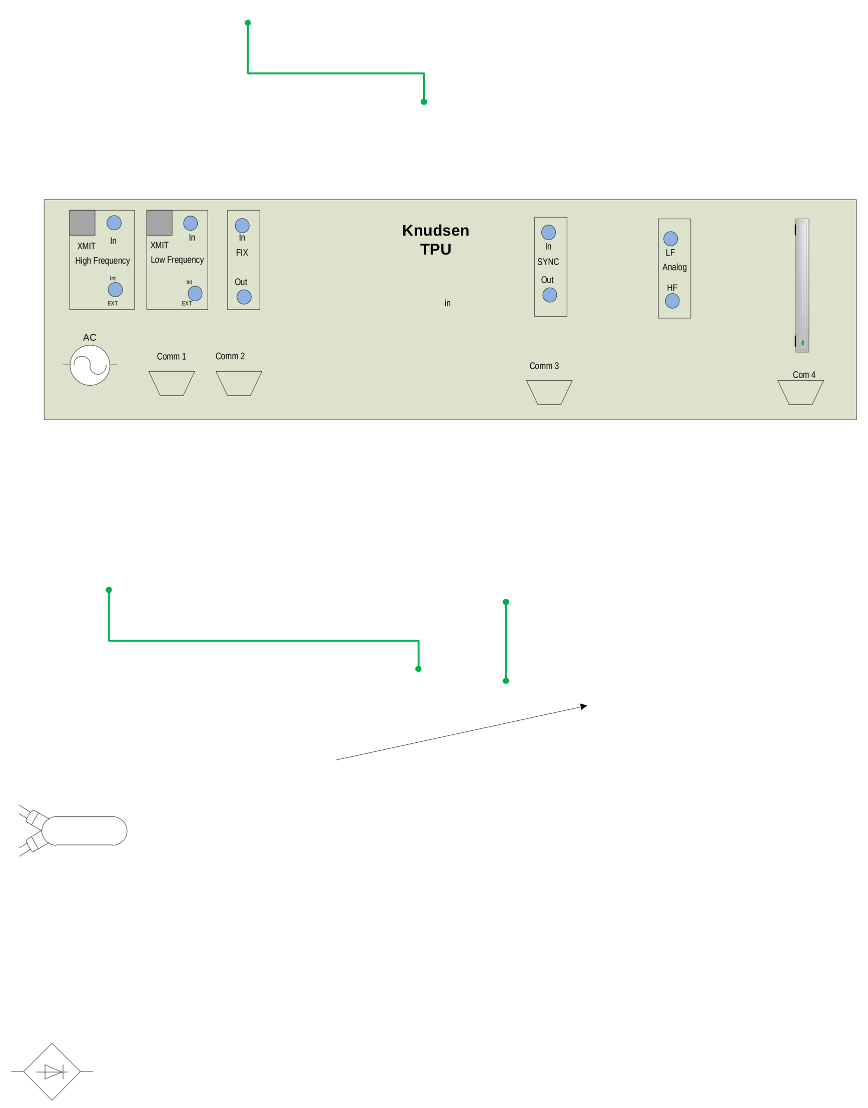
NMEA output
Com 3 9600 n,8,1,N, Hard
DBT, GGA VTG
No Flow

Order
Hardware Applanix
Hysweep Inter

Hysweep Reson
Apppanix
SSS cable towfish.dll

SSS CPU
May switch between COM 3
and Com 4 9600, N ,8,1 n





Knudsen
TPU
XMIT
In
High Frequency
Int
EXT
XMIT
In
Low Frequency
Int
EXT
In
FIX
Out
in
In
SYNC
Out
LF
Analog
HF
AC
Comm 1
Comm 2
Comm 3
Com 4

Certificate of Calibration

Customer:	NOAA, Group : NOAA - Marine Operations Center Atlantic
Asset Serial Number:	007591
Asset Product Type:	Micro SV&P for Brooke MVP -
Calibration Type:	Pressure
Calibration Range:	1000 dBar
Calibration RMS Error:	.0618
Calibration ID:	007591 129146 0TE599 110117 135946
Installed On:	

Coefficient A:	-2.574511E+3	Coefficient H:	-5.916234E-15
Coefficient B:	1.820538E-1	Coefficient I:	-1.762720E-5
Coefficient C:	-4.133096E-6	Coefficient J:	1.123850E-9
Coefficient D:	2.932489E-11	Coefficient K:	-2.388330E-14
Coefficient E:	5.711829E-1	Coefficient L:	1.691618E-19
Coefficient F:	-3.660197E-5	Coefficient M:	0.000000E+0
Coefficient G:	8.071607E-10	Coefficient N:	0.000000E+0

Calibration Date (dd/mm/yyyy): 11/1/2017

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, Group : NOAA - Marine Operations Center Atlantic
Asset Serial Number:	007591
Asset Product Type:	Micro SV&P for Brooke MVP -
Calibration Type:	Sound Velocity
Calibration Range:	1400 to 1600 m/s
Calibration RMS Error:	.0093
Calibration ID:	007591 999999 007591 100117 233849
Installed On:	

Coefficient A:	7.156975E-4	Coefficient H:	0.000000E+0
Coefficient B:	-7.460850E-5	Coefficient I:	0.000000E+0
Coefficient C:	1.536302E-6	Coefficient J:	0.000000E+0
Coefficient D:	-1.085566E-6	Coefficient K:	0.000000E+0
Coefficient E:	0.000000E+0	Coefficient L:	0.000000E+0
Coefficient F:	0.000000E+0	Coefficient M:	0.000000E+0
Coefficient G:	0.000000E+0	Coefficient N:	0.000000E+0

Calibration Date (dd/mm/yyyy): 10/1/2017

Certified By:

AML Oceanographic

Robert Haydock

President, AML Oceanographic

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Certificate of Calibration

Customer:	NOAA, Group : NOAA - Marine Operations Center Atlantic
Asset Serial Number:	004988
Asset Product Type:	Smart SV&P for Brooke MVP -
Calibration Type:	Pressure
Calibration Range:	1000 dBar
Calibration RMS Error:	.0631
Calibration ID:	004988 021407 0XE111 100117 131604
Installed On:	

Coefficient A:	-1.568758E+3	Coefficient H:	-5.412054E-9
Coefficient B:	-8.337370E-1	Coefficient I:	8.917691E-9
Coefficient C:	2.784933E-3	Coefficient J:	-2.154370E-11
Coefficient D:	1.651412E-4	Coefficient K:	-1.798432E-12
Coefficient E:	4.766431E-2	Coefficient L:	3.779060E-14
Coefficient F:	2.482477E-5	Coefficient M:	0.000000E+0
Coefficient G:	-7.050158E-8	Coefficient N:	0.000000E+0

Calibration Date (dd/mm/yyyy): 10/1/2017

Certified By:

AML Oceanographic

Robert Haydock

President, AML Oceanographic

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AML OCEANOGRAPHIC
Xchange your old ideas

Certificate of Calibration

Customer: NOAA, Group : NOAA - Marine Operations Center Atlantic
Asset Serial Number: 004988
Asset Product Type: Smart SV&P for Brooke MVP -
Calibration Type: Sound Velocity
Calibration Range: 1400 to 1550 m/s
Calibration RMS Error: .0166
Calibration ID: 004988 999999 004988 120117 000051
Installed On:

Coefficient A: 1.529719E+3
Coefficient B: -1.114755E+2
Coefficient C: 8.040022E+0
Coefficient D: -3.198663E-1
Coefficient E: 0.000000E+0
Coefficient F: 0.000000E+0
Coefficient G: 0.000000E+0

Coefficient H: 0.000000E+0
Coefficient I: 0.000000E+0
Coefficient J: 0.000000E+0
Coefficient K: 0.000000E+0
Coefficient L: 0.000000E+0
Coefficient M: 0.000000E+0
Coefficient N: 0.000000E+0

Calibration Date (dd/mm/yyyy): 12/1/2017
Certified By:

Robert Haydock
President, AML Oceanographic

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Certificate of Calibration

Customer:	NOAA, Group : NOAA - Marine Operations Center Atlantic
Asset Serial Number:	005340
Asset Product Type:	Smart SV&P for Brooke MVP -
Calibration Type:	Pressure
Calibration Range:	1000 dBar
Calibration RMS Error:	.0559
Calibration ID:	005340 127028 0TE689 100117 131612
Installed On:	

Coefficient A:	-1.918293E+3	Coefficient H:	1.044152E-8
Coefficient B:	-1.399663E+0	Coefficient I:	1.183152E-8
Coefficient C:	2.217375E-2	Coefficient J:	-1.508418E-10
Coefficient D:	-1.520440E-4	Coefficient K:	8.793572E-12
Coefficient E:	5.852037E-2	Coefficient L:	-1.896560E-13
Coefficient F:	4.658058E-5	Coefficient M:	0.000000E+0
Coefficient G:	-9.419392E-7	Coefficient N:	0.000000E+0

Calibration Date (dd/mm/yyyy): 10/1/2017

Certified By:

AML Oceanographic

Robert Haydock

President, AML Oceanographic

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Certificate of Calibration

Customer:	NOAA, Group : NOAA - Marine Operations Center Atlantic
Asset Serial Number:	005340
Asset Product Type:	Smart SV&P for Brooke MVP -
Calibration Type:	Sound Velocity
Calibration Range:	1400 to 1550 m/s
Calibration RMS Error:	.0145
Calibration ID:	005340 126551 201222 120117 000053
Installed On:	

Coefficient A:	1.530656E+3	Coefficient H:	0.000000E+0
Coefficient B:	-1.074837E+2	Coefficient I:	0.000000E+0
Coefficient C:	8.311876E+0	Coefficient J:	0.000000E+0
Coefficient D:	-6.944922E-1	Coefficient K:	0.000000E+0
Coefficient E:	0.000000E+0	Coefficient L:	0.000000E+0
Coefficient F:	0.000000E+0	Coefficient M:	0.000000E+0
Coefficient G:	0.000000E+0	Coefficient N:	0.000000E+0

Calibration Date (dd/mm/yyyy): 12/1/2017

Certified By:

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President, AML Oceanographic

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Certificate of Calibration

Customer:	NOAA, Group : NOAA - Marine Operations Center Atlantic
Asset Serial Number:	007761
Asset Product Type:	ZZZMicro CTD, Fixed Sensors, for Brooke MVP -
Calibration Type:	Conductivity
Calibration Range:	0 to 70 mS/cm
Calibration RMS Error:	.0005
Calibration ID:	007761 888888 007761 160117 111158
Installed On:	

Coefficient A:	-1.074501E-2	Coefficient H:	-2.228472E-14
Coefficient B:	5.559353E-7	Coefficient I:	0.000000E+0
Coefficient C:	-3.134133E-9	Coefficient J:	0.000000E+0
Coefficient D:	9.582428E-12	Coefficient K:	0.000000E+0
Coefficient E:	2.498840E-5	Coefficient L:	0.000000E+0
Coefficient F:	-1.292873E-9	Coefficient M:	0.000000E+0
Coefficient G:	7.288683E-12	Coefficient N:	0.000000E+0

Calibration Date (dd/mm/yyyy): 16/1/2017

Certified By:

AML Oceanographic

Robert Haydock

President, AML Oceanographic

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Certificate of Calibration

Customer:	NOAA, Group : NOAA - Marine Operations Center Atlantic
Asset Serial Number:	007761
Asset Product Type:	ZZZMicro CTD, Fixed Sensors, for Brooke MVP -
Calibration Type:	Temperature
Calibration Range:	-2 to +32 Dec C
Calibration RMS Error:	.0003
Calibration ID:	007761 999999 007761 160117 110656
Installed On:	

Coefficient A:	-8.823676E+0	Coefficient H:	0.000000E+0
Coefficient B:	8.660855E-4	Coefficient I:	0.000000E+0
Coefficient C:	-8.246224E-9	Coefficient J:	0.000000E+0
Coefficient D:	1.424515E-13	Coefficient K:	0.000000E+0
Coefficient E:	-1.216148E-18	Coefficient L:	0.000000E+0
Coefficient F:	5.530362E-24	Coefficient M:	0.000000E+0
Coefficient G:	1.186240E-29	Coefficient N:	0.000000E+0

Calibration Date (dd/mm/yyyy): 16/1/2017

Certified By:

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T: +1-250-656-0771 F: +1-250-655-3655 Email: service@AMLoceanographic.com

Certificate of Calibration

Customer:	NOAA, Group : NOAA - Marine Operations Center Atlantic
Asset Serial Number:	007761
Asset Product Type:	ZZZMicro CTD, Fixed Sensors, for Brooke MVP -
Calibration Type:	Pressure
Calibration Range:	1000 dBar
Calibration RMS Error:	.0797
Calibration ID:	007761 777777 007761 180117 111630
Installed On:	

Coefficient A:	1.809074E+4	Coefficient H:	1.051234E-14
Coefficient B:	-1.220359E+0	Coefficient I:	-8.862022E-6
Coefficient C:	2.749514E-5	Coefficient J:	6.218871E-10
Coefficient D:	-2.090448E-10	Coefficient K:	-1.454745E-14
Coefficient E:	-9.632677E-1	Coefficient L:	1.134265E-19
Coefficient F:	6.501725E-5	Coefficient M:	0.000000E+0
Coefficient G:	-1.432178E-9	Coefficient N:	0.000000E+0

Calibration Date (dd/mm/yyyy): 18/1/2017

Certified By:

AML Oceanographic

Robert Haydock

President, AML Oceanographic

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SonTek

a xylem brand

9940 Summers Ridge Road
San Diego, CA 92121
Tel: (858) 546-8327
support@sontek.com

CALIBRATION CERTIFICATE

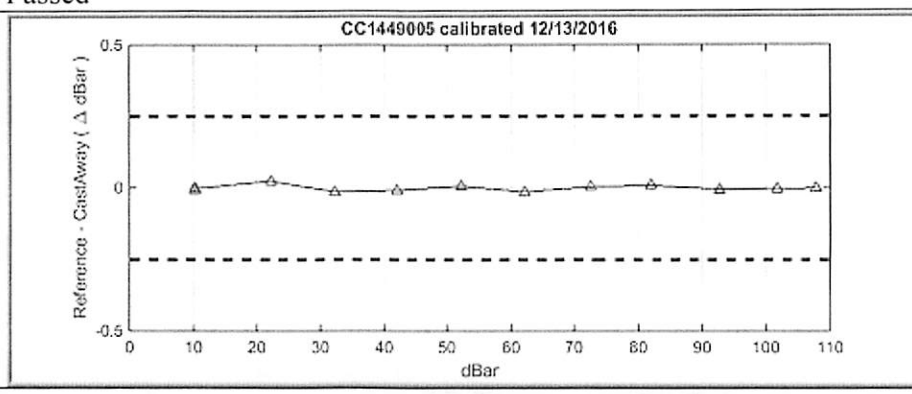
SYSTEM INFO

System Type	CastAway-CTD
Serial Number	CC1449005
Firmware Version	1.60
Date	01/03/2017

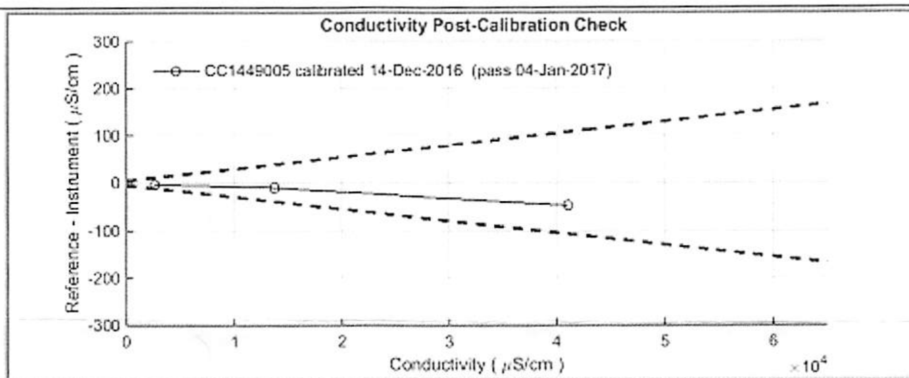
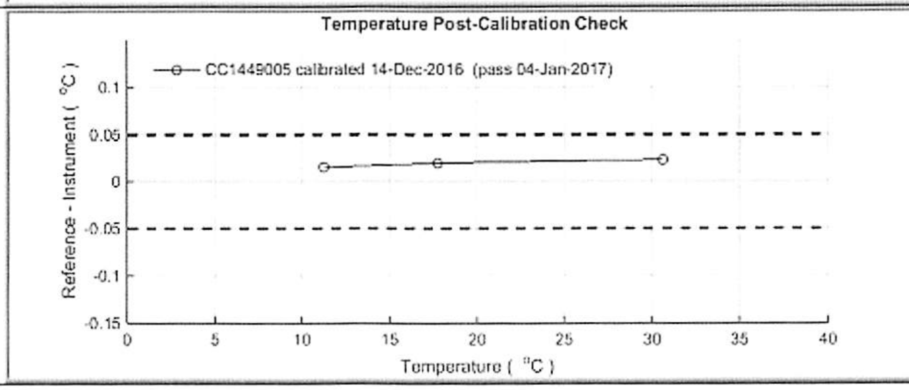
POWER CONSUMPTION

Standby Mode (A)	0.1937 / PASS
Supply Voltage	2.9V

CALIBRATION

GPS	Passed
Pressure	

a xylem brand
9949 Summers Ridge Road • San Diego, CA 92121 • Telephone (858) 546-8327 • Fax (858) 546-8150 • Internet: www.sontek.com

Conductivity	
Temperature	

Verified by: Thanh.Nguyen
This report was generated on: 1/4/2017

ATTENTION: New Warranty Terms as of March 4, 2013:
This system is covered under a two year limited warranty that extends to all parts and labor for any malfunction due to workmanship or errors in the manufacturing process. The warranty is valid only if you properly maintain and operate this system under normal use as outlined in the User's Manual. The warranty does not cover shortcomings that are due to the design, or any incidental damages as a result of errors in the measurements.
SonTek will repair and/or replace, at its sole option, any product established to be defective with a product of like type. CLAIMS FOR LABOR COSTS AND/OR OTHER CHARGES RESULTING FROM THE USE OF SonTek GOODS AND/OR PRODUCTS ARE NOT COVERED BY THIS LIMITED WARRANTY.
SonTek DISCLAIMS ALL EXPRESS WARRANTIES OTHER THAN THOSE CONTAINED ABOVE AND ALL IMPLIED WARRANTIES, INCLUDING BUT NOT LIMITED TO WARRANTIES OF MERCHANTABILITY AND/OR FITNESS FOR A PARTICULAR PURPOSE. SonTek DISCLAIMS AND WILL NOT BE LIABLE, UNDER ANY CIRCUMSTANCE, IN CONTRACT, TORT OR WARRANTY, FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES OF ANY KIND, INCLUDING BUT NOT LIMITED TO LOST PROFITS, BUSINESS INTERRUPTION LOSSES, LOSS OF GOODWILL, OR LOSS OF BUSINESS OR CUSTOMER RELATIONSHIPS.
If your system is not functioning properly, first try to identify the source of the problem. If additional support is required, we encourage you to contact us immediately. We will work to resolve the problem as quickly as possible.
If the system needs to be returned to the factory, please contact SonTek to obtain a Service Request (SR) number. We reserve the right to refuse receipt of shipments without SRs. We require the system to be shipped back in the original shipping container using the original packing material with all delivery costs covered by the customer (including all taxes and duties). If the system is returned without appropriate packing, the customer will be required to cover the cost of a new packaging crate and material.
The warranty for repairs performed at an authorized SonTek Service Center is one year.

PLEASE FILL IN THE INFORMATION ON THIS PAGE, AND THEN PLACE THIS PAGE INSIDE THE SHIPPING BOX.

Service Request # 323605

Ship (Bill) to Address: 439 West York Street
Norfolk, VA 23510
USA

CUSTOMER CONTACT INFORMATION

Bill to:	Ship to:
Michael N Peperato	NOAA Thomas Jefferson; Chief ET
439 West York Street	439 West York Street
Norfolk, VA 23510	Norfolk, VA 23510

Tel: (757) 441-6458

E-mail: michael.peperato@noaa.gov

RECEIVED
DEC 01 2016
BY:

INSTRUMENT INFORMATION

Serial Number: CC1449005

Briefly describe reason for return (if applicable, include events leading to problem): CastAway Calibration

Yearly Calibration required by program specifications for Hydrographic Data Collection.

List contents of shipping box:

This serves as your packing list to us. List each separated item (e.g., system, cables, plugs, ...). We use this list to ensure we return the correct items to you.

Castaway CTD, Yellow carrying case, YSI orange protective cover for CTD, One stainless steel shackle, plastic bag with two cleaning brushes, two O-Rings and a tube of lube, Case with 2 batteries (AA) an orange thumb drive and a blue tooth key, Orange neck strap with plastic pen device attached, and a rope with a stainless steel shackle, various documents.

(LIC)
All Assy

Yellow
CASE
12x10x5

SONTEK SERVICE REQUEST INSTRUCTIONS

Please follow these instructions to assure prompt attention to your instrument.

1. Please package the instrument in the original box in which the instrument was shipped to you. If it is not possible to use the original box, please package it securely in a sturdy container with substantial packing to prevent possible damage during shipping. If the instrument is shipped to SonTek without such precautions, we reserve the right to refuse the shipment and/or charge for proper packaging upon return to you.

2. Please address the shipping box as follows:

SonTek
ATTN: SR# 323605
9940 Summers Ridge Road
San Diego, CA 92121-3091
United States
Tel: +1 858-546-8327

3. FOR INTERNATIONAL CUSTOMERS ONLY: If the instrument is being returned from outside the United States: please be sure to state clearly on all paperwork (commercial invoice and SLI) "U.S. GOODS RETURNING FOR REPAIR". Ensure you use HTS code: 9801.10.0000 when returning an instrument. Please complete the attached Foreign Shipper's Declaration. 4. SonTek will not accept shipments sent "FREIGHT COLLECT." All returned items must be shipped freight prepaid unless otherwise authorized.

4. FOR INTERNATIONAL CUSTOMERS ONLY: Please ship all instruments "D.D.P. (Delivered Duties Paid) SAN DIEGO". If these instructions are not followed, SonTek reserves the right to bill any charges incurred for duties and taxes to you.

5. SonTek will not accept shipments sent "FREIGHT COLLECT." All returned items must be shipped freight prepaid unless otherwise authorized.

6. We suggest you remove used battery packs before shipping. If you return an instrument to us with a used battery pack, and you wish to have the pack replaced, we must charge an additional $20 U.S. to cover the cost of government-required battery disposal.

7. Instruments returned outside of the warranty period are subject to an evaluation fee of $400. Additional charges for parts and labor may be necessary.

8. Instruments must be cleaned and dried prior to return to SonTek for repairs. If your system has an internal recorder, please be sure to download all files before returning the system. We are not responsible for lost data.

9. Please fill in the second page of this form and place it in the returning shipping box. Keep this first page for your records.

IF YOU HAVE ANY QUESTIONS REGARDING THESE INSTRUCTIONS, PLEASE CONTACT US BEFORE RETURNING THE INSTRUMENT.

Sound Velocity Calibration Sheet	
Remarks:	
Date:	13-Dec-16
S/N:	2999

2 Way Gap Distance	
(meters)	0.127
Svel Calibration Coef.	
Offset	-1909
Span	10130

Do Not Enter Data On This Sheet

Input Data		Ref. Data	Ref T.O.F.	T.O.F. Linear Regression Data			corr T.O.F.	corr SVEL	stdev 0.081
deg. C	TOF ns (x)	Del Grosso	(ns) (y)	xy	x²	y²	(ns)	(m/s)	Δ vel
4.00	90065	1421.569	89338	8046176834	8111620362	7981261297	89329	1421.71	0.143
5.00	89803	1426.098	89054	7997372053	8064654680	7930650757	89064	1425.93	-0.163
6.00	89525	1430.523	88779	7947904488	8014704799	7881660939	88782	1430.47	-0.057
7.00	89261	1434.846	88511	7900567583	7967457011	7834239713	88515	1434.79	-0.053
8.00	89004	1439.068	88252	7854753350	7921736018	7788337057	88255	1439.02	-0.051
9.00	88755	1443.191	87999	7810420997	7877508393	7743904938	88003	1443.14	-0.052
10.00	88508	1447.215	87755	7766990051	7833650125	7700897218	87752	1447.26	0.045
11.00	88274	1451.142	87517	7725509915	7792323152	7659269550	87515	1451.18	0.034
12.00	88048	1454.974	87287	7685398721	7752397173	7618979289	87286	1454.99	0.016
13.00	87816	1458.712	87063	7645564359	7711710675	7579985406	87051	1458.91	0.196
14.00	87610	1462.357	86846	7608621085	7675577856	7542248402	86843	1462.41	0.056
15.00	87405	1465.910	86636	7572418057	7639698391	7505730239	86635	1465.92	0.009
16.00	87195	1469.373	86431	7536418264	7603025796	7470394258	86422	1469.53	0.155
17.00	87010	1472.747	86233	7503183133	7570764422	7436205116	86235	1472.72	-0.022
18.00	86820	1476.033	86041	7470100067	7537677264	7403128718	86042	1476.03	-0.008
19.00	86630	1479.233	85855	7437669044	7504806538	7371132157	85850	1479.33	0.093
20.00	86465	1482.348	85675	7407889921	7476220714	7340183654	85683	1482.21	-0.134
21.00	86283	1485.380	85500	7377200801	7444762221	7310252504	85498	1485.41	0.032
22.00	86119	1488.329	85331	7348602771	7416518449	7281309021	85332	1488.30	-0.028
23.00	85962	1491.198	85166	7321063601	7389435328	7253324493	85173	1491.09	-0.110
24.00	85805	1493.986	85007	7294067675	7362500286	7226271128	85014	1493.87	-0.113
25.00	85643	1496.697	84854	7267110834	7334722906	7200122016	84850	1496.76	0.066
26.00	85499	1499.330	84704	7242137182	7310054296	7174851081	84704	1499.34	0.013
27.00	85361	1501.888	84560	7218140623	7286489328	7150433042	84564	1501.82	-0.067
28.00	85223	1504.372	84421	7194618486	7263038124	7126843378	84425	1504.30	-0.074
29.00	85086	1506.782	84286	7171558439	7239699952	7104058286	84286	1506.78	-0.007
30.00	84961	1509.121	84155	7149904954	7218405305	7082054650	84159	1509.05	-0.074
31.00	84831	1511.390	84029	7128204873	7196243019	7060810004	84027	1511.42	0.032
32.00	84717	1513.589	83907	7108349567	7177054326	7040302507	83912	1513.49	-0.103
33.00	84593	1515.721	83788	7087949187	7156035275	7020510904	83786	1515.76	0.037
34.00	84481	1517.787	83674	7068885685	7137007070	7001414506	83672	1517.82	0.037
35.00	84374	1519.788	83564	7050668881	7119000487	6982993156	83564	1519.79	-0.002
36.00	84268	1521.725	83458	7032816646	7101061963	6965227207	83457	1521.75	0.024
37.00	84162	1523.599	83355	7015319146	7083191156	6948097494	83349	1523.71	0.111
38.00	84073	1525.413	83256	6999556558	7068194328	6931585315	83259	1525.36	-0.050
39.00	83972	1527.167	83161	6983196430	7051379757	6915672403	83157	1527.22	0.056
40.00	83884	1528.863	83068	6968079860	7036483791	6900340906	83068	1528.88	0.013

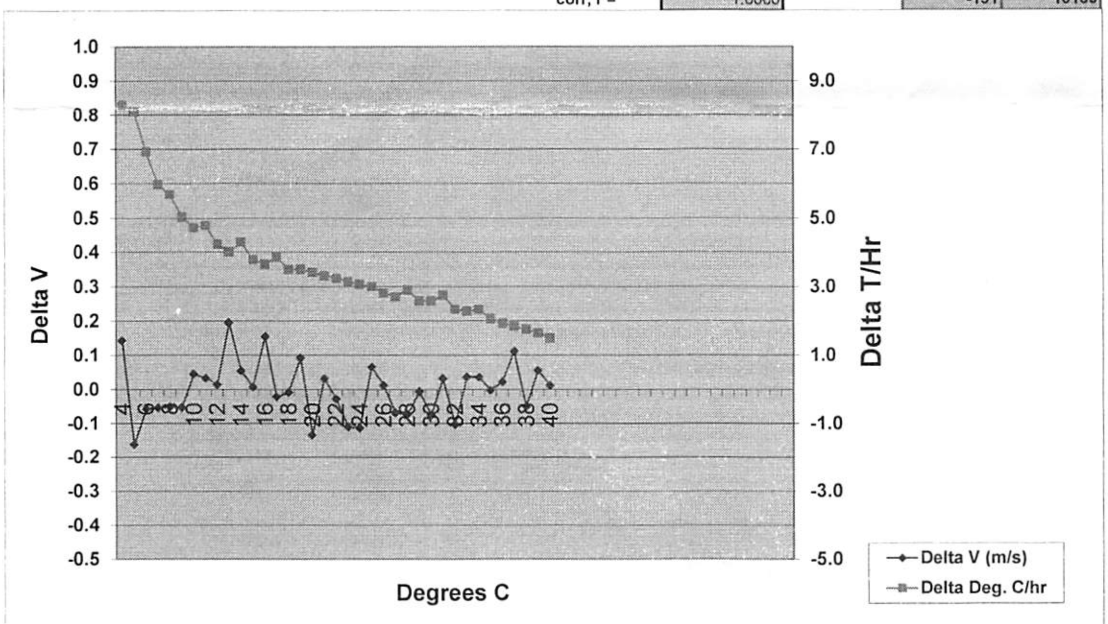
n	Σ(x)	Σ(y)	Σ(xy)	Σ(x²)	Σ(y²)
37	3197493.20	3.169E+06	2.739E+11	2.764E+11	2.715E+11

(Σx)²	(Σy)²
1.0224E+13	1.004E+13

	Output
slope, m =	1.013
y int, b =	-1909
corr, r =	1.0000

Calibration Constants	
Offset	Span
-1909	10130

Probe Cal. Constants	
SVEL_K1	SVEL_K2
-191	10130



Survey Equipment Services, Inc.

GOODS OUT 2016005

Customer Ref : RMA # 527621
CF# : RF-793
Type : Calibration

Bill To: Teledyne-Reson, Inc.
5212 Verdugo Way
Camarillo, CA 93012

Ship To: Teledyne-Reson, Inc.
5212 Verdugo Way
Camarillo, CA 93012
Attn: Kelly Wright

Item	Qty	Description	Serial No.	Notes
1	1	Teledyne Odom Digibar V ** End	002999	

DELIVERY DETAILS:

Ship Via FEDEX

Tracking# 777952124116

Ship Date 12/14/2016 **Signature** ______________________

TELEPHONE: 281-829-6481

1775 WESTBOROUGH DRIVE
WESTBOROUGH BUSINESS PARK
KATY, TX 77449

Goods Out

ORIGIN ID:NQIA (281) 829-6481
ALAN CRAIG
SURVEY EQUIPMENT SERVICES
1775 WESTBOROUGH DRIVE

KATY, TX 77449
UNITED STATES US

SHIP DATE: 14DEC16
ACTWGT: 3.00 LB
CAD: 5711675/INET3790
DIMS: 15x16x6 IN

BILL RECIPIENT

TO **KELLY WRIGHT**
TELEDYNE RESON, INC.
5212 VERDUGO WAY

CAMARILLO CA 93012
(805) 964-6260 REF: RMA 527621 / RF793
INV:
PO: DEPT:

544J1/D42F/14E8

FedEx Express

E

J162016101201uv

THU - 15 DEC 3:00P
STANDARD OVERNIGHT

TRK# 0201 **7779 5212 4116**

93012
CA-US **BUR**

A7 OXRA

After printing this label:
1. Use the 'Print' button on this page to print your label to your laser or inkjet printer.
2. Fold the printed page along the horizontal line.
3. Place label in shipping pouch and affix it to your shipment so that the barcode portion of the label can be read and scanned.

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Use of this system constitutes your agreement to the service conditions in the current FedEx Service Guide, available on fedex.com.FedEx will not be responsible for any claim in excess of $100 per package, whether the result of loss, damage, delay, non-delivery,misdelivery,or misinformation, unless you declare a higher value, pay an additional charge, document your actual loss and file a timely claim.Limitations found in the current FedEx Service Guide apply. Your right to recover from FedEx for any loss, including intrinsic value of the package, loss of sales, income interest, profit, attorney's fees, costs, and other forms of damage whether direct, incidental,consequential, or special is limited to the greater of $100 or the authorized declared value. Recovery cannot exceed actual documented loss.Maximum for items of extraordinary value is $1,000, e.g. jewelry, precious metals, negotiable instruments and other items listed in our ServiceGuide. Written claims must be filed within strict time limits, see current FedEx Service Guide.

Launch 1

TELEDYNE RESON
Everywhereyoulook™

SVP Test and Calibration certificate

Valid for surface use*

SVP Type :	SVP71
SVP Serial No.	0710064

Date of issue :	2/21/2017

Temperature Calibration :	Fluke Hart 1504 s/n B38892 & Thermistor pn AS115 s/n 3702
Point 1:	4.5 °C
Point 2:	16.5 °C
Point 3:	25.5 °C

	RMS Speed of Sound Errors
Temperature Validation :	0.0404 m/s

Calibration & Final Function Test : Sign : ______________________

QA Signature : Inits : ____________

* Surface use: 0 to 20m water depth.

Launch 2

TELEDYNE RESON
Everywhereyoulook™

SVP Test and Calibration certificate

Valid for surface use*

SVP Type :	SVP71
SVP Serial No.	4211065

Date of issue :	2017-02-23

Temperature Calibration :	Fluke Hart 1504 s/n B38892 & Thermistor pn AS115 s/n 3702
Point 1:	4.5 ℃
Point 2:	16.5 ℃
Point 3:	25.5 ℃

	RMS Speed of Sound Errors
Temperature Validation :	0.0033 m/s

Calibration & Final Function Test : Sign : ______________________

QA Signature : Inits : KG TL

* Surface use: 0 to 20m water depth.

TELEDYNE RESON
Everywhereyoulook™
TELEDYNE-RESON California, USA
Phone: +1 805 233-3900

Spare

TELEDYNE RESON
Everywhereyoulook™

SVP Test and Calibration certificate

Valid for surface use*

SVP Type :	SVP71
SVP Serial No.	4211067

Date of issue :	2017-03-01

Temperature Calibration :	Fluke Hart 1504 s/n B38892 & Thermistor pn AS115 s/n 3702
Point 1:	4.5 ℃
Point 2:	16.5 ℃
Point 3:	25.5 ℃

	RMS Speed of Sound Errors
Temperature Validation :	0.0228 m/s

Calibration & Final Function Test : Sign : ______________

QA Signature : Inits : ______________

* Surface use: 0 to 20m water depth.

TELEDYNE RESON
Everywhereyoulook™
TELEDYNE-RESON California, USA
Phone: +1 805 233-3900

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: 0285
CALIBRATION DATE: 04-Feb-17

SBE 19 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

```
g =  -4.07300858e+000
h =   4.85735412e-001
i =   1.25061470e-003
j =  -2.43321316e-005
```

```
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

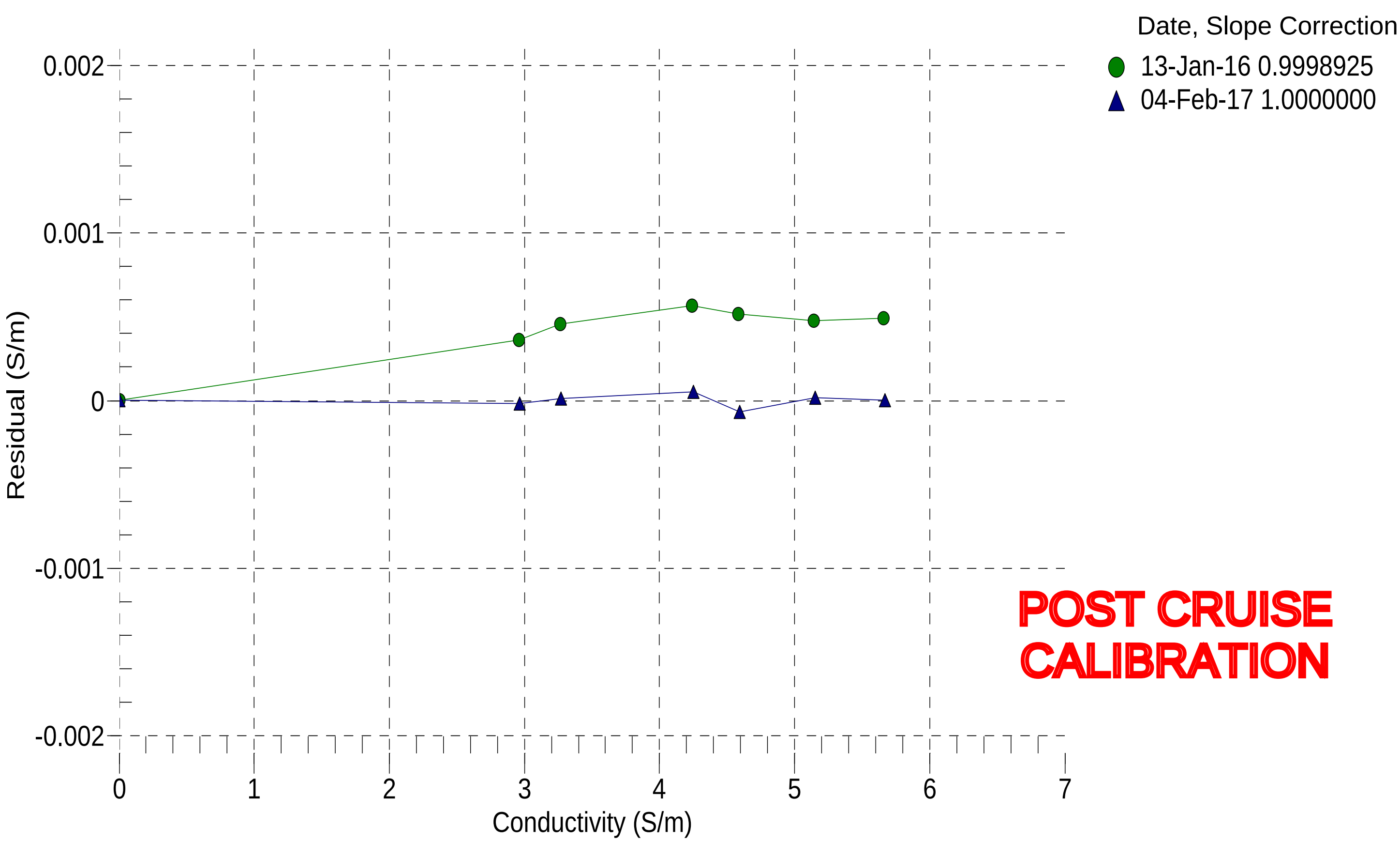
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2.88563	0.00000	0.00000
1.0000	34.6919	2.96634	8.26052	2.96633	-0.00002
4.5000	34.6716	3.27241	8.62451	3.27243	0.00001
15.0000	34.6283	4.25098	9.69552	4.25103	0.00005
18.4999	34.6191	4.59501	10.04437	4.59495	-0.00007
24.0000	34.6090	5.15119	10.58391	5.15120	0.00002
29.0000	34.6036	5.67139	11.06429	5.67139	0.00000
32.5000	34.5999	6.04251	11.39475	6.04287	0.00037

f = Instrument Output (kHz)

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.

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: 0285
CALIBRATION DATE: 02-Feb-17

SBE 19 PRESSURE CALIBRATION DATA
FSR: 5000 psia S/N 133807 TCV:

QUADRATIC COEFFICIENTS:
PA0 = 2.490724e+003
PA1 = -6.503266e-001
PA2 = -5.697540e-008

STRAIGHT LINE FIT:
M = -6.503518e-001
B = 2.490383e+003

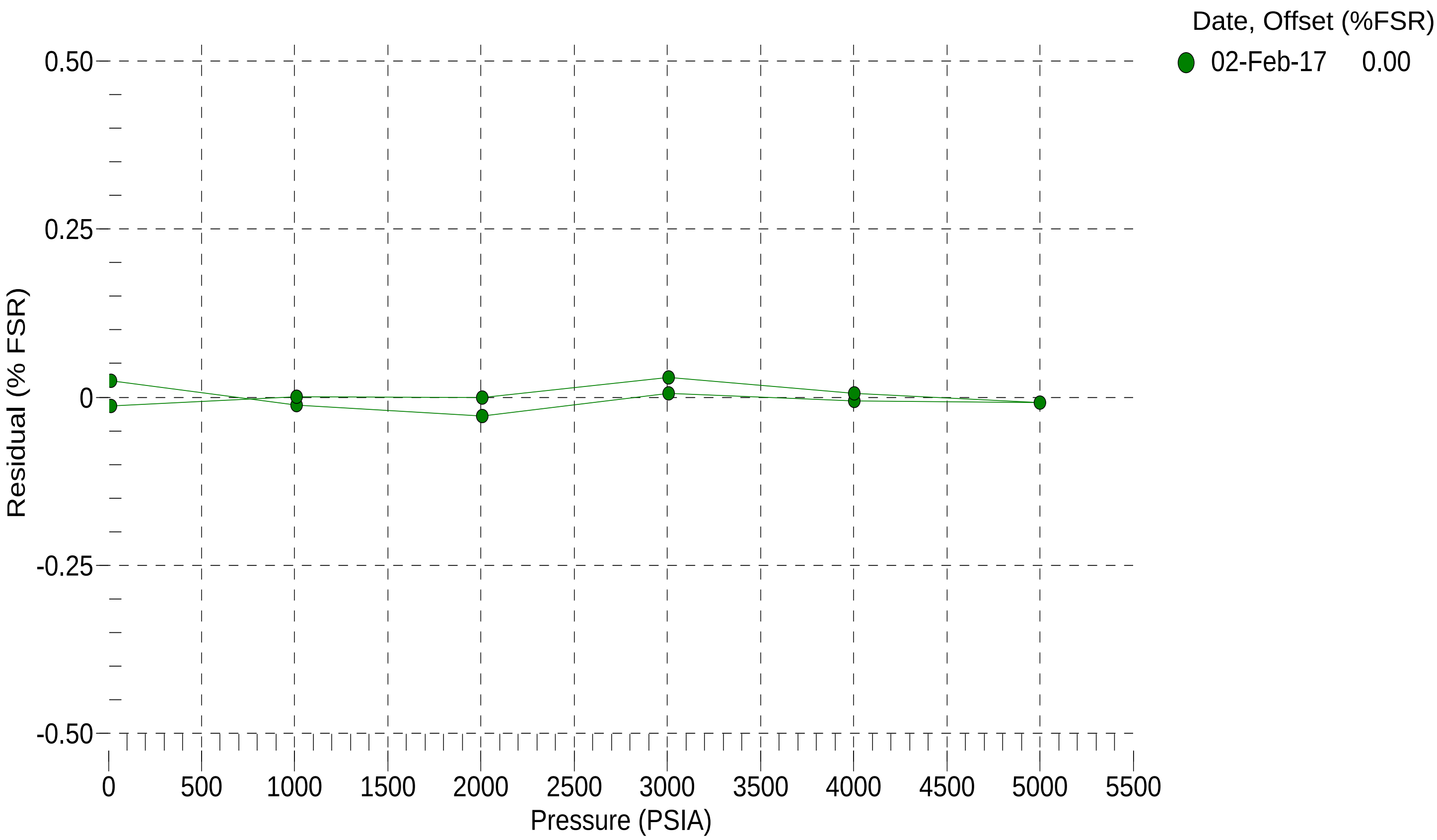
PRESSURE (PSIA)	INSTRUMENT OUTPUT (counts)	COMPUTED PRESSURE (PSIA)	RESIDUAL (%FSR)	LINEAR FIT (PSIA)	LINEAR RESIDUAL (%FSR)
14.70	3804.2	15.93	0.02	16.32	0.03
1011.18	2275.5	1010.61	-0.01	1010.51	-0.01
2008.45	743.7	2007.04	-0.03	2006.72	-0.03
3005.51	-792.1	3005.81	0.01	3005.53	0.00
4002.69	-2325.0	4002.43	-0.01	4002.45	-0.00
4999.88	-3859.0	4999.49	-0.01	5000.09	0.00
4002.67	-2325.8	4002.95	0.01	4002.97	0.01
3005.59	-794.0	3007.05	0.03	3006.76	0.02
2008.49	741.5	2008.48	-0.00	2008.15	-0.01
1011.21	2274.5	1011.26	0.00	1011.16	-0.00
14.70	3807.1	14.04	-0.01	14.43	-0.01

n = instrument output (counts)

Straight Line Fit: Pressure (PSIA) = M * n + B

Quadratic Fit: 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: 0285
CALIBRATION DATE: 04-Feb-17

SBE 19 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

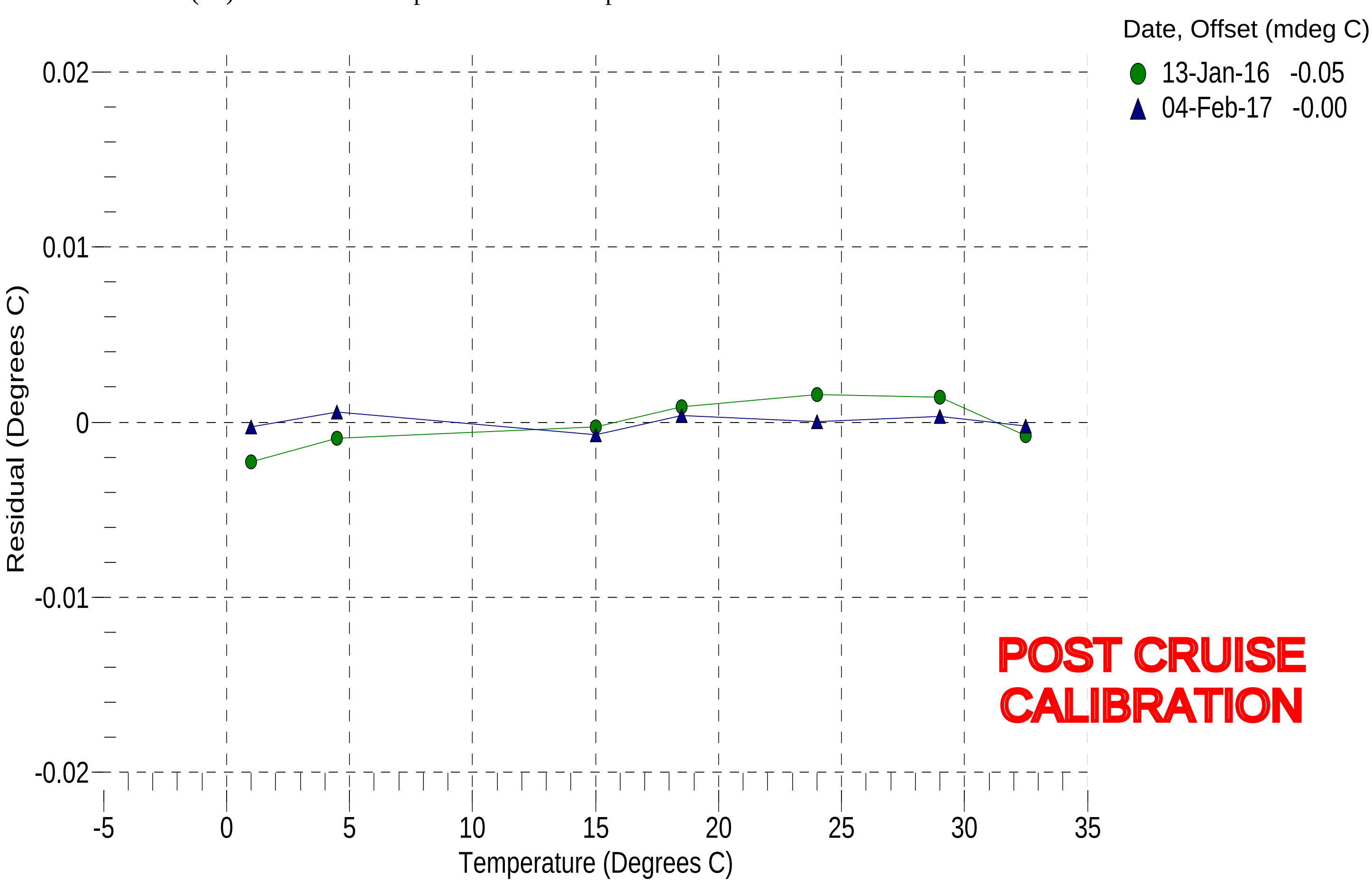
COEFFICIENTS:
g = 4.12462544e-003
h = 5.73988694e-004
i = -2.18662915e-006
j = -3.51142872e-006
f0 = 1000.0

BATH TEMP (° C)	INSTRUMENT OUTPUT (Hz)	INST TEMP (° C)	RESIDUAL (° C)
1.0000	2297.642	0.9997	-0.00029
4.5000	2490.797	4.5006	0.00056
15.0000	3139.048	14.9993	-0.00072
18.4999	3379.484	18.5003	0.00036
24.0000	3783.134	24.0000	0.00002
29.0000	4178.755	29.0003	0.00033
32.5000	4472.483	32.4998	-0.00025

f = Instrument Output (Hz)

Temperature ITS-90 (°C) = $1/\{g + h[\mathit{ln}(f0 / f)] + i[\mathit{ln}^2(f0 / f)] + j[\mathit{ln}^3(f0 / f)]\} - 273.15$

Residual (°C) = instrument temperature - bath temperature



Sea-Bird Electronics, Inc.
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SENSOR SERIAL NUMBER: 4487
CALIBRATION DATE: 09-Feb-17

SBE 19plus CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:
g = -1.021501e+000
h = 1.395833e-001
i = -2.272578e-004
j = 3.739346e-005

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

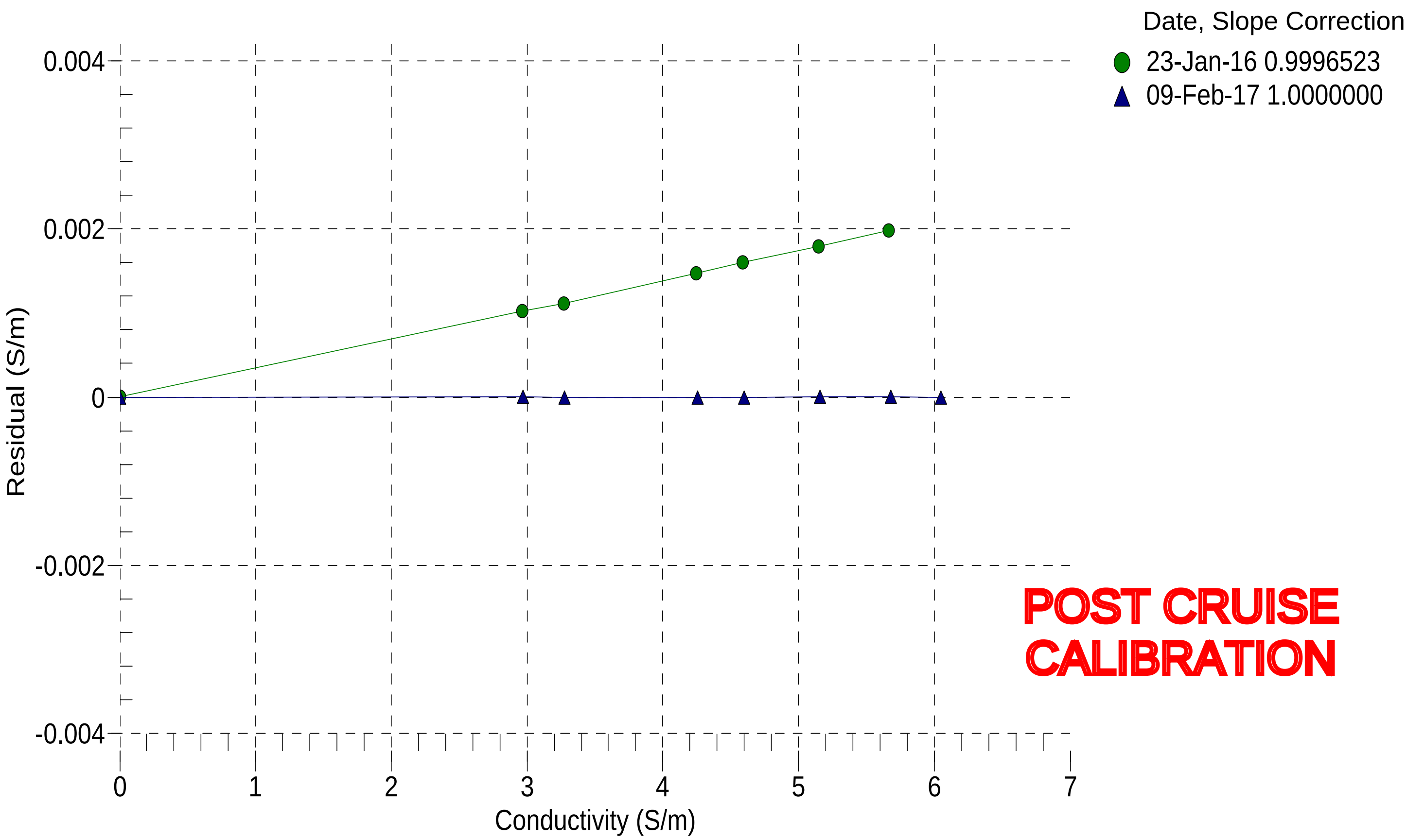
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2708.53	0.0000	0.00000
0.9999	34.7331	2.96952	5349.99	2.9695	0.00001
4.4999	34.7132	3.27595	5550.86	3.2759	-0.00001
15.0000	34.6702	4.25558	6148.42	4.2556	-0.00000
18.4999	34.6611	4.59999	6344.84	4.6000	-0.00001
23.9999	34.6509	5.15672	6649.80	5.1567	0.00001
29.0000	34.6450	5.67741	6922.50	5.6774	0.00001
32.4999	34.6415	6.04894	7110.48	6.0489	-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

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: 4487
CALIBRATION DATE: 08-Feb-17

SBE 19plus PRESSURE CALIBRATION DATA
508 psia S/N 2837

COEFFICIENTS:

```
PA0 =      7.902702e-002
PA1 =      1.556410e-003
PA2 =      7.504087e-012
PTEMPA0 = -7.458082e+001
PTEMPA1 =  4.921759e+001
PTEMPA2 = -4.134267e-001
```

```
PTCA0 =  5.242735e+005
PTCA1 =  4.122209e+000
PTCA2 = -8.153683e-002
PTCB0 =  2.498675e+001
PTCB1 = -5.000000e-005
PTCB2 =  0.000000e+000
```

PRESSURE SPAN CALIBRATION

PRESSURE (PSIA)	INSTRUMENT OUTPUT (counts)	THERMISTOR OUTPUT (volts)	COMPUTED PRESSURE (PSIA)	RESIDUAL (%FSR)
14.55	533615.0	2.0	14.54	-0.00
104.80	591580.0	2.0	104.79	-0.00
204.80	655756.0	2.0	204.78	-0.00
304.80	719907.0	2.0	304.79	-0.00
404.80	784022.0	2.0	404.80	-0.00
504.81	848095.0	2.0	504.81	-0.00
404.81	784038.0	2.0	404.82	0.00
304.80	719930.0	2.0	304.82	0.00
204.81	655777.0	2.0	204.81	0.00
104.81	591599.0	2.0	104.82	0.00
14.54	533618.0	2.0	14.55	0.00

THERMAL CORRECTION

TEMP (°C)	THERMISTOR OUTPUT (volts)	INSTRUMENT OUTPUT (counts)
32.50	2.22	533779.44
29.00	2.14	533776.33
24.00	2.04	533779.33
18.50	1.92	533778.52
15.00	1.85	533773.55
4.50	1.63	533745.35
1.00	1.56	533732.58

TEMPERATURE (°C)	SPAN (mV)
-5.00	24.99
35.00	24.98

y = thermistor output (counts)

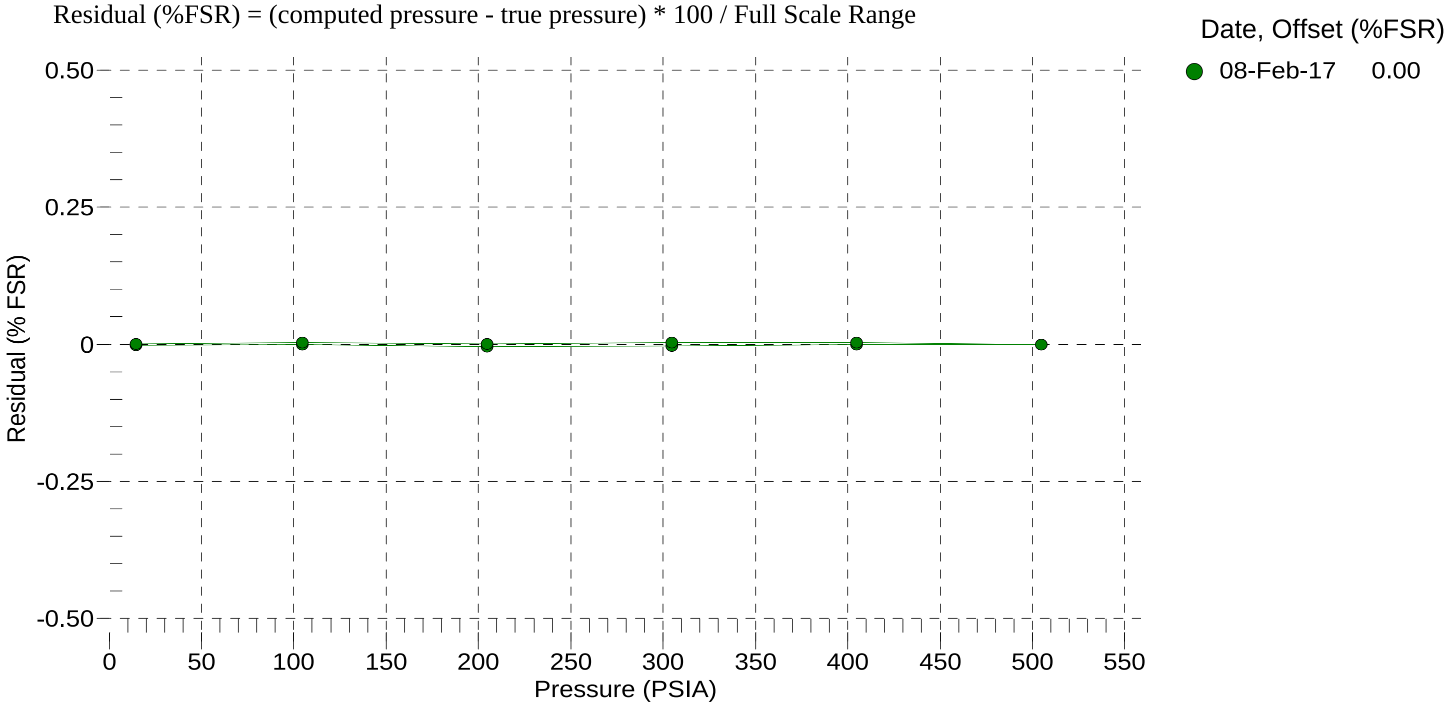
$t = PTEMPA0 + PTEMPA1 * y + PTEMPA2 * y^2$

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

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

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

Residual (%FSR) = (computed pressure - true pressure) * 100 / Full Scale Range



Sea-Bird Electronics, Inc.

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

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SENSOR SERIAL NUMBER: 4487
CALIBRATION DATE: 09-Feb-17

SBE 19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

a0 = 1.215545e-003
a1 = 2.605569e-004
a2 = 5.437772e-008
a3 = 1.423267e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
0.9999	713487.169	1.0000	0.0001
4.4999	638173.119	4.4997	-0.0002
15.0000	447181.034	15.0002	0.0002
18.4999	394913.932	18.4999	-0.0000
23.9999	323274.949	23.9999	-0.0000
29.0000	268226.508	28.9998	-0.0002
32.4999	234759.458	32.5000	0.0001

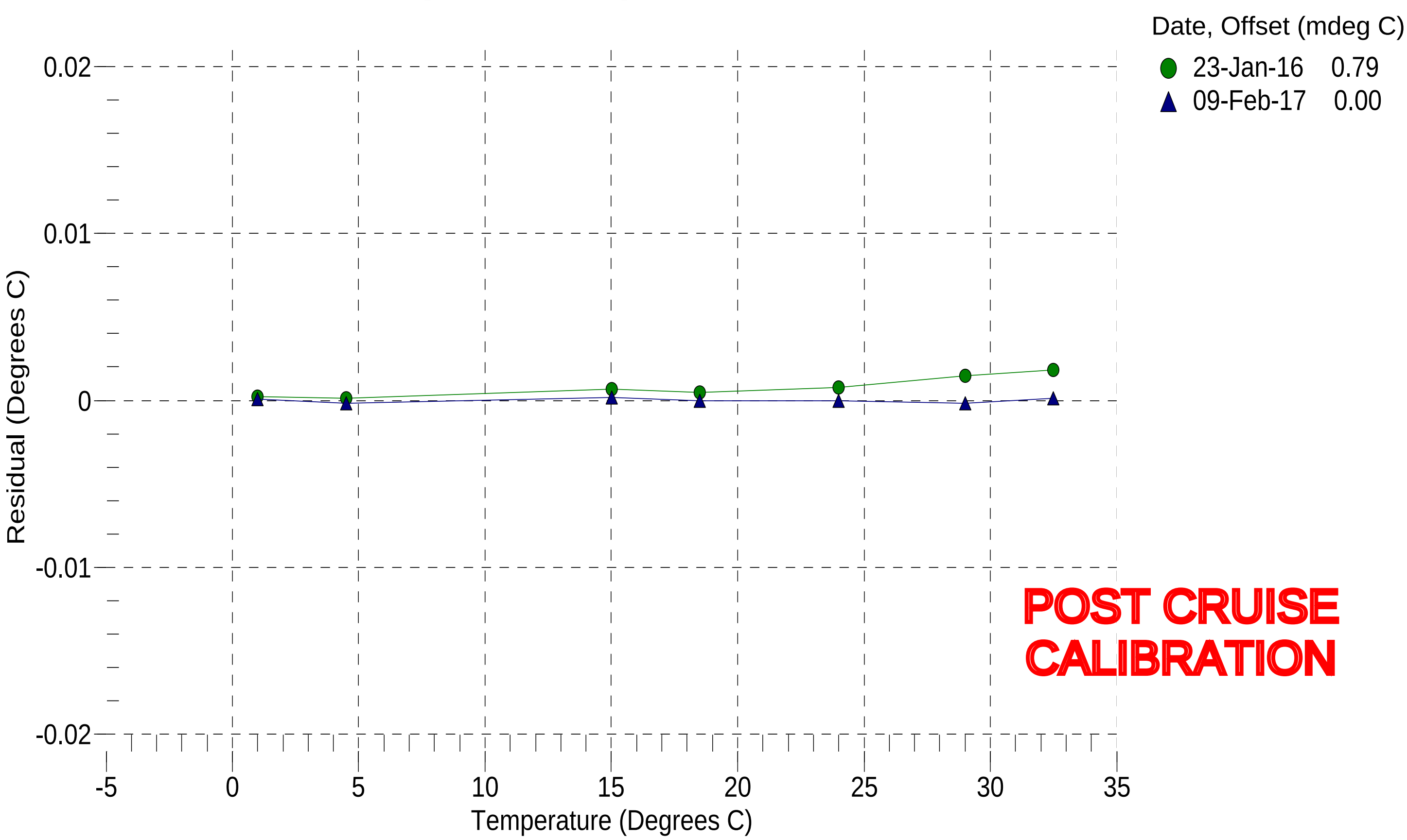
n = Instrument Output (counts)

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



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: 6667
CALIBRATION DATE: 04-Feb-17

SBE 19plus V2 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -1.022646e+000
h = 1.341336e-001
i = 1.899491e-005
j = 1.690591e-005

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

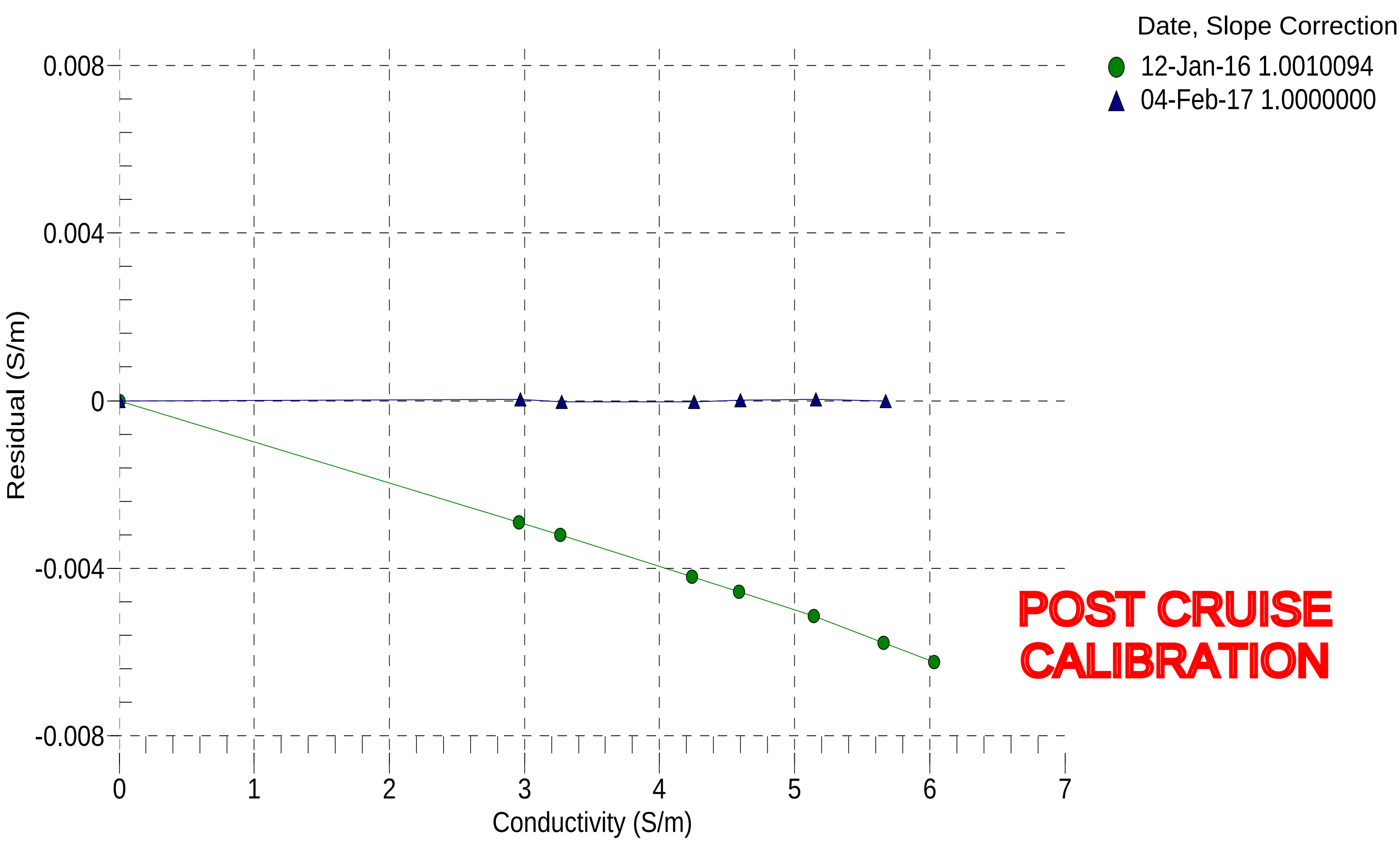
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2759.31	0.0000	0.00000
0.9999	34.7252	2.96891	5442.88	2.9689	0.00003
4.5000	34.7051	3.27526	5646.99	3.2752	-0.00003
15.0000	34.6625	4.25474	6254.44	4.2547	-0.00003
18.5000	34.6533	4.59907	6454.20	4.5991	0.00002
23.9999	34.6433	5.15572	6764.37	5.1557	0.00003
28.9999	34.6378	5.67635	7041.82	5.6763	-0.00002
32.4999	34.6344	6.04784	7233.11	6.0478	-0.00008

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



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: 6667
CALIBRATION DATE: 1-Feb-17

SBE 19plus V2 PRESSURE CALIBRATION DATA
870 psia S/N 3182130

COEFFICIENTS:

PA0 = 1.976211e+000	PTCA0 = 5.245898e+005
PA1 = 2.627526e-003	PTCA1 = 5.242476e+001
PA2 = 2.272074e-011	PTCA2 = -8.443841e-001
PTEMPA0 = -6.624888e+001	PTCB0 = 2.523813e+001
PTEMPA1 = 5.265826e+001	PTCB1 = -9.750000e-004
PTEMPA2 = -5.577237e-001	PTCB2 = 0.000000e+000

PRESSURE SPAN CALIBRATION

PRESSURE (PSIA)	INSTRUMENT OUTPUT (counts)	THERMISTOR OUTPUT (volts)	COMPUTED PRESSURE (PSIA)	RESIDUAL (%FSR)
14.73	530184.0	1.7	14.71	-0.00
179.99	592967.0	1.7	179.92	-0.01
359.99	661302.0	1.7	359.95	-0.00
539.99	729548.0	1.7	539.95	-0.01
719.99	797721.0	1.7	719.97	-0.00
869.98	854460.0	1.7	869.96	-0.00
720.00	797750.0	1.7	720.05	0.01
540.02	729592.0	1.7	540.07	0.01
360.02	661343.0	1.7	360.06	0.00
180.00	593013.0	1.7	180.04	0.00
14.73	530204.0	1.7	14.76	0.00

THERMAL CORRECTION

TEMP (°C)	THERMISTOR OUTPUT (volts)	INSTRUMENT OUTPUT (counts)
32.50	1.91	530246.47
29.00	1.85	530232.78
24.00	1.75	530193.61
18.50	1.64	530111.08
15.00	1.57	530031.02
4.50	1.36	529645.46
1.00	1.29	529479.46

TEMPERATURE (°C)	SPAN (mV)
-5.00	25.24
35.00	25.20

y = thermistor output (counts)

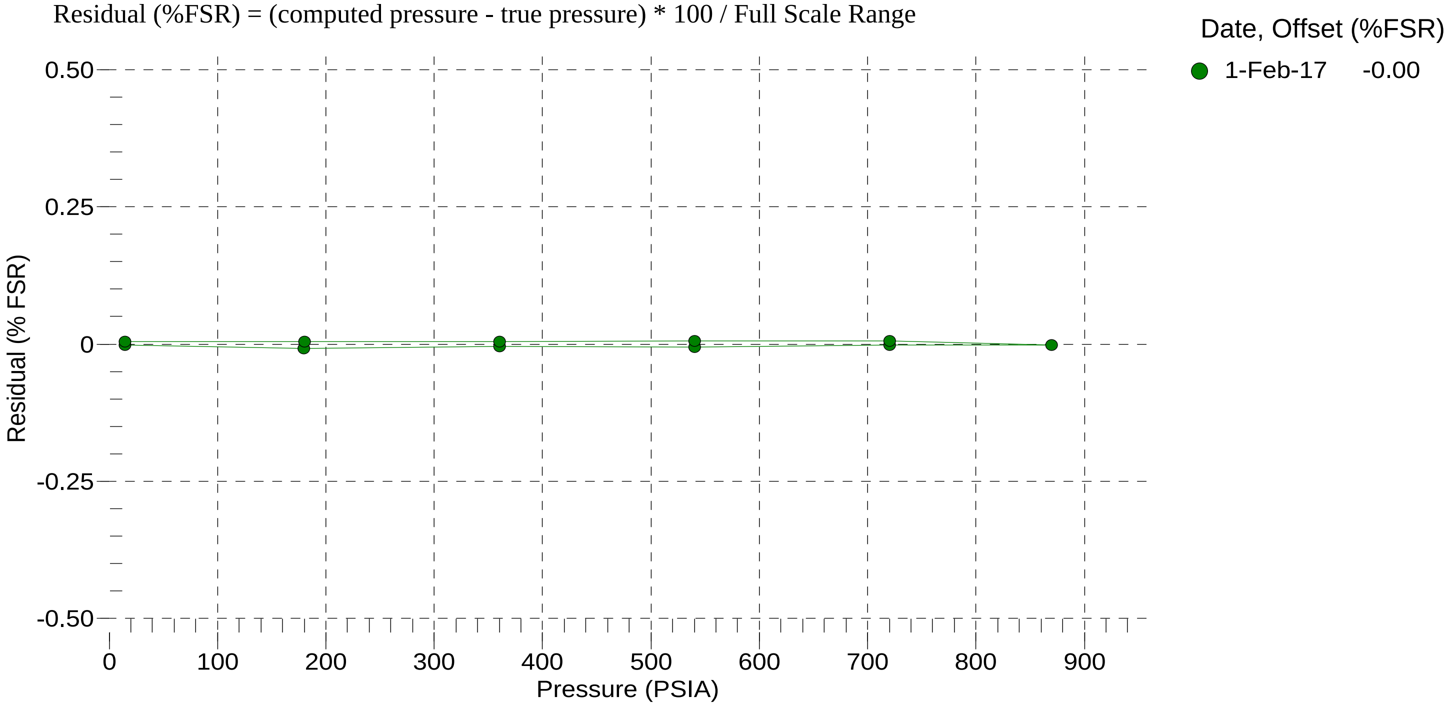
$t = PTEMPA0 + PTEMPA1 * y + PTEMPA2 * y^2$

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

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

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

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: 6667
CALIBRATION DATE: 04-Feb-17

SBE 19plus V2 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

a0 = 1.251506e-003
a1 = 2.577880e-004
a2 = 5.786759e-008
a3 = 1.355261e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
0.9999	702154.983	1.0000	0.0001
4.5000	626329.220	4.4998	-0.0002
15.0000	435066.729	15.0001	0.0001
18.5000	383031.661	18.5000	0.0000
23.9999	311981.153	23.9998	-0.0001
28.9999	257617.390	28.9998	-0.0001
32.4999	224680.966	32.5000	0.0001

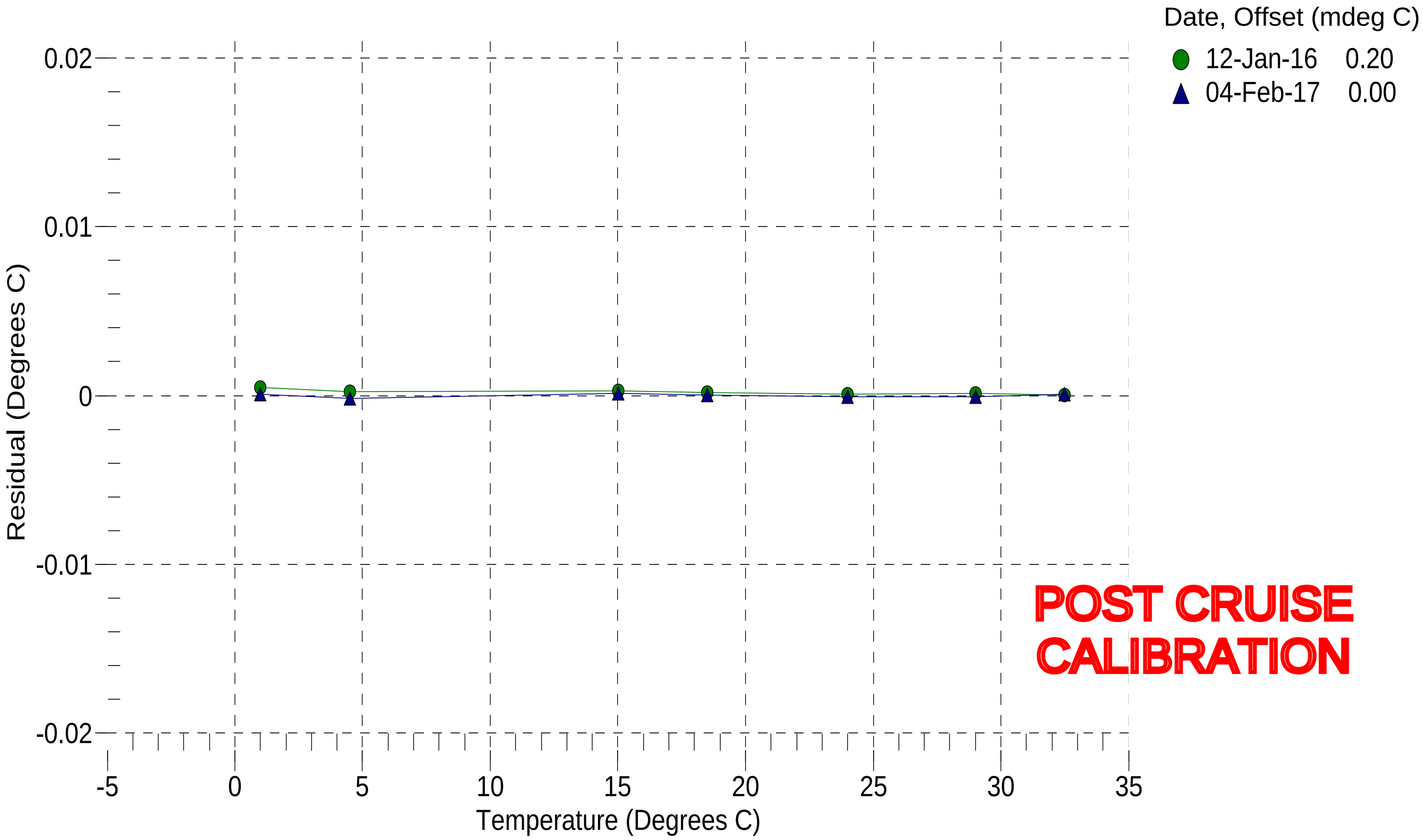
n = Instrument Output (counts)

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



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: 0491
CALIBRATION DATE: 14-Feb-17

SBE 45 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

```
g = -9.962091e-001
h =  1.739383e-001
i = -8.973398e-004
j =  9.105236e-005

CPcor = -9.5700e-008
CTcor =  3.2500e-006
WBOTC =  2.4322e-007
```

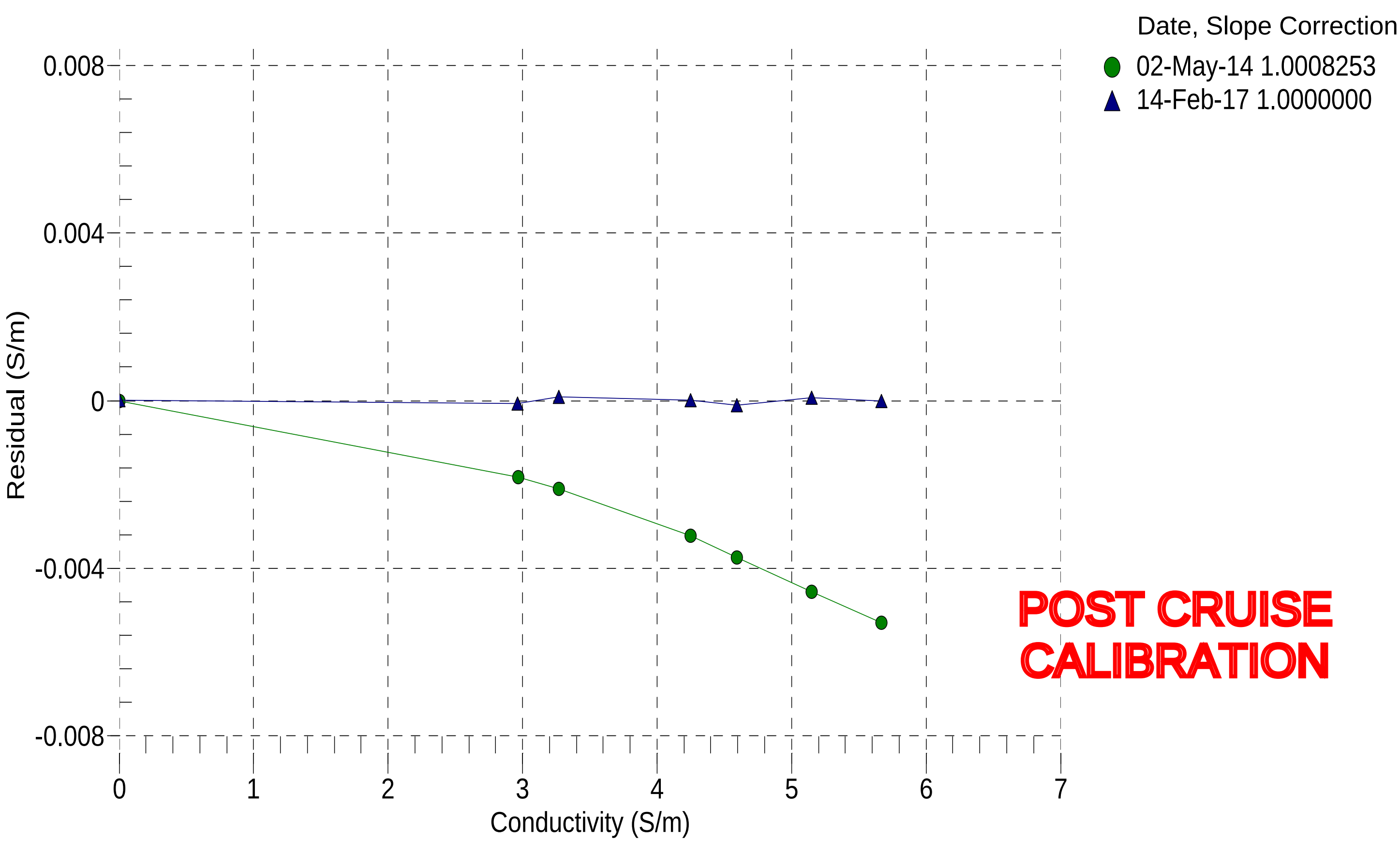
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2404.49	0.00000	0.00000
1.0000	34.6748	2.96502	4802.75	2.96495	-0.00007
4.4999	34.6554	3.27103	4984.94	3.27112	0.00009
15.0000	34.6139	4.24940	5526.44	4.24942	0.00002
18.5000	34.6049	4.59334	5704.33	4.59324	-0.00010
24.0000	34.5949	5.14932	5980.64	5.14939	0.00007
29.0000	34.5892	5.66929	6227.55	5.66928	-0.00002
32.5000	34.5852	6.04023	6397.76	6.04030	0.00006

f = Instrument Output(Hz) * sqrt(1.0 + WBOTC * t) / 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



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: 0491
CALIBRATION DATE: 14-Feb-17

SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

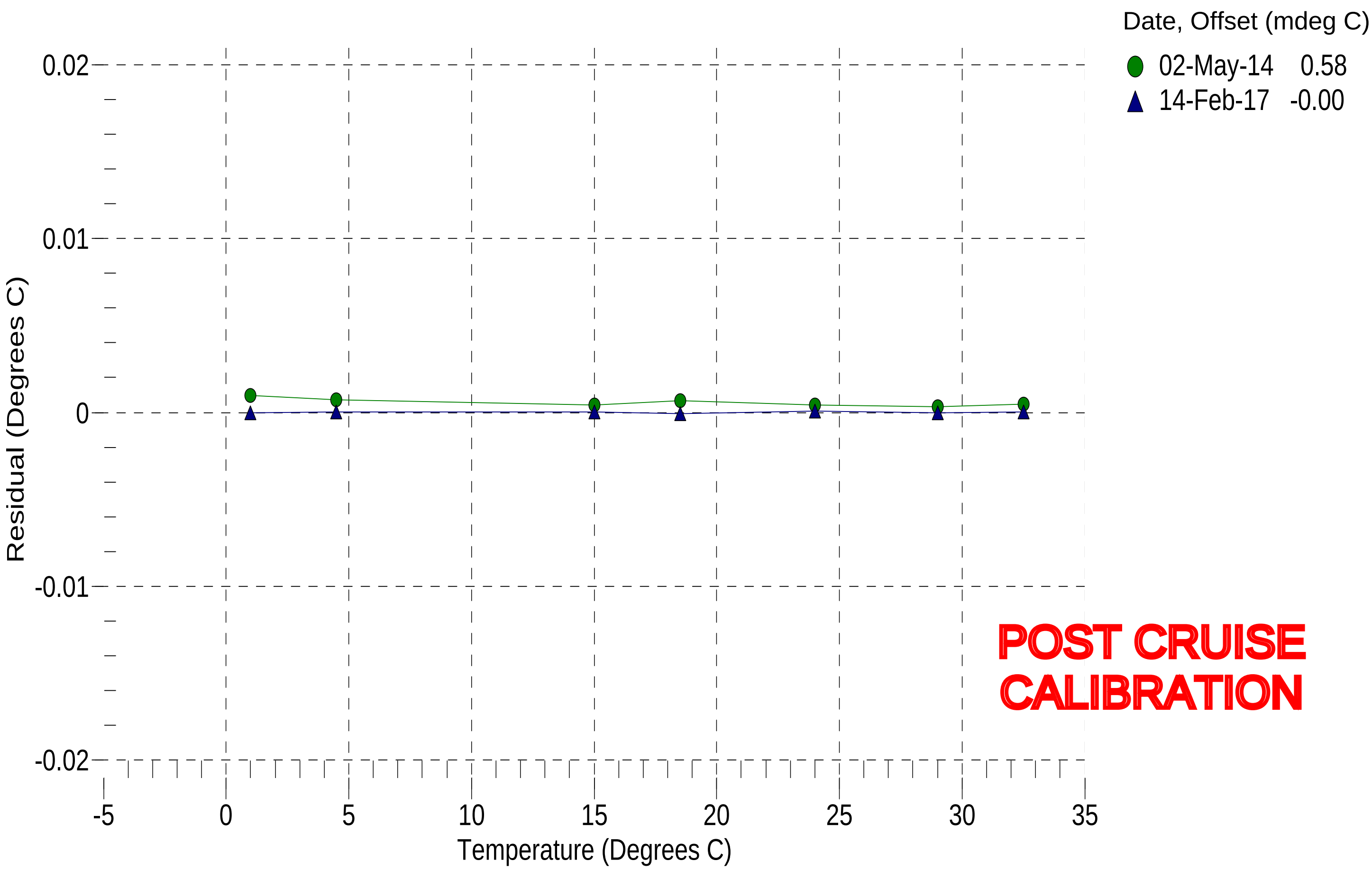
COEFFICIENTS:
a0 = 5.259318e-005
a1 = 2.652908e-004
a2 = -1.825040e-006
a3 = 1.335895e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
1.0000	775047.8	1.0000	-0.0000
4.4999	661016.5	4.4999	0.0000
15.0000	418258.0	15.0000	0.0000
18.5000	361339.7	18.4999	-0.0001
24.0000	288859.5	24.0001	0.0001
29.0000	237117.2	29.0000	-0.0000
32.5000	207207.9	32.5000	0.0000

n = Instrument Output (counts)

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

Residual (°C) = instrument temperature - bath temperature



TELEDYNE RESON
Everywhereyoulook™

SVP Test and Calibration certificate

Valid for surface use*

SVP Type :	SVP70
SVP Serial No.	0217007

Date of issue :	2017-05-16
RMA	527642

Temperature Calibration :	Fluke Hart 1504 s/n B38892 & Thermistor pn AS115 s/n 3702
Point 1:	4.5 ℃
Point 2:	16.5 ℃
Point 3:	25.6 ℃

	RMS Speed of Sound Errors
Temperature Validation :	0.0032 m/s

Calibration & Final Function Test : Sign : ____________

QA Signature : Inits : ____________

* Surface use: 0 to 20m water depth.

TELEDYNE RESON
Everywhereyoulook™
TELEDYNE-RESON California, USA
Phone: +1 805 964-6260

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.

Calibration Certificate Number:	**47566**
Instrument Type:	**Tidemaster**
Instrument Serial Number:	**33711**
Calibrated By:	**R.Musgrove**
Date:	**14/12/2016**
Signed:	

Full details of the results from the calibration procedure applied to each fitted sensor are available, on request, via email. This summary certificate should be kept with the instrument.

Valeport Ltd | St Peter's Quay | Totnes | Devon | TQ9 5EW | UK
T: +44 (0) 1803 869292
E: sales@valeport.co.uk | www.valeport.co.uk

Valeport Calibration Worksheet - 4008231B

Sound Velocity

Transducer Type, mm	50
Transducer Ser No	52297
PCB Type	400 round
PCB Part No	0400554
PCB Ser No	53049
SV Firmware Version	04007149B0
FPGA Firmware Version	0650714C
Module Number	12

As Received Spot Check

	SOS from unit	SOS from Standard	Error
Fresh	1410.925	1412.662	-1.737
Saline	#	#	#VALUE!
#VALUE!			

Temp °C90	SoS m/s	Measured ToF nsec*100	Calc ToF nsec*100	Meas-Calc ToF nsec	STAB	Half path mm	Total path mm
Low Temperature							
2.0894	1412.664	7447432	7078825	3686.07		50	100
2.0893	1412.663	7447438	7078827	3686.11	STAB	50	100
2.0896	1412.665	7447433	7078820	3686.13		50	100
#	#VALUE!	#	#VALUE!	#VALUE!		50	100
#	#VALUE!	#	#VALUE!	#VALUE!		50	100
High Temperature							
15.9095	1469.091	7176304	6806931	3693.73		50	100
15.9092	1469.090	7176315	6806936	3693.79		50	100
15.9094	1469.091	7176311	6806933	3693.78	STAB	50	100
#	#VALUE!	#	#VALUE!	#VALUE!		50	100
#	#VALUE!	#	#VALUE!	#VALUE!		50	100

Enter Last 6 bytes of characterisation string
7
10
10
8
4
-3
Characterised OK

Return Signal Voltage
700mV

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
2.0893	1412.663	7447438	3.885920E+05	1412.663	0.000	±0.001	Pass
15.9094	1469.091	7176311	1.002831E+07	1469.090	0.000	±0.001	Pass

Stage 2: Enter calibration string

#024;12;1;15;0;0;0;0;1.002831E+07;3.885920E+05

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
15.9094	1469.091	1469.092	0.001	±0.005	Pass

Stage 4: Reference Check

Reference SoS m/s	Sensor SoS m/s	Error SoS Reading-Actual m/s	Acceptable Error m/s	Pass/Fail
#	#	#VALUE!	±0.010	#VALUE!

Name:	R Musgrove
Date:	14/12/2016
Signature:	

VALEPORT

The original manufacture warranty on your instrument has expired. However, we are pleased to provide you with our 12 month Service Warranty on your instrument, which is renewed each time you return the device for service.

Service Warranty Policy

The instrument detailed below is returned to you after Service with a Limited 12 Month Warranty against defects in materials and workmanship, valid from the date of despatch from Valeport's premises, with the following exclusions, exceptions and limitations:

1) Sensors supplied by other manufacturers (including pressure sensors) are only warranted according to the warranty period provided by the original manufacturer (typically 1 year), and are thus excluded from this Warranty.
2) Consumable items (including, but not limited to: batteries, o-rings, zinc anodes and electrolytes) are not covered by warranty.
3) Reasonable wear and tear (as judged by Valeport) is not covered by warranty.
4) Valeport Limited shall be under no liability for any consequential loss or damage of any kind whatsoever.
5) Correctly performed standard maintenance procedures as described in the operating manual will not invalidate the warranty. Failures caused by improper care and handling, or by unskilled or poor quality repair and maintenance attempts are not covered under warranty. Modifications to the original design will invalidate the warranty, insofar as it relates to the modified part.
6) All warranty repairs must be performed by Valeport personnel or their authorized representatives.
7) Valeport Limited is the sole judge of the cause of any failure, and the validity of any warranty claim. Please refer to the "Spirit of the Warranty" section below.

- Goods for warranty assessment should be adequately packed (preferably in the original packing) and returned freight pre-paid to Valeport, complete with a description of the nature of the problem. It is preferable that an RMA (Returns Number) is obtained from us in advance, to allow us to schedule the repair.
- All warranty claims are assessed on a case-by-case basis. You will be informed as soon as possible as to the validity of the warranty claim.
- In the event of a valid warranty claim, the goods will be repaired or replaced as appropriate at the sole discretion of Valeport Limited. The repaired / replacement instrument will be returned to you at our cost, using our choice of shipping method.
- In the event of an invalid warranty claim, you will be informed of any repairs that are necessary, and if acceptable, the instrument will be repaired as if it had been returned for service, with appropriate costs and return freight charges payable by you.
- Any repairs made under warranty shall have no effect on the duration of the warranty period, i.e. the warranty shall continue as if no fault had occurred.
- Valeport may, at our discretion, opt to despatch a replacement part for fitting in the field, if it is deemed to be the most appropriate response. In such circumstances, the user will be required to return the faulty part to Valeport (at the user's cost) for assessment and confirmation that the failure is a valid warranty claim. Failure to return the faulty part, or if the fault is subsequently judged to fall outside the terms of the warranty, shall result in the user being invoiced for the replacement part and freight costs.

Spirit of the Warranty

This warranty is offered on the basis that Valeport fully expects the instrument to perform satisfactorily for many years. We have built a reputation on reliability, longevity and quality, and therefore the aim of this warranty is your satisfaction and peace of mind. The "rules" as detailed above are the framework within which we operate our warranty policy, and the minimum that you can expect from us in resolving any warranty issue. However, each case is considered on its own merit, and we may decide that in certain circumstances, alternative arrangements or solutions to a warranty issue are appropriate. Equally, we hope that our customers accept this warranty in the spirit in which it is given, and to respect that whilst our primary concern is always to try and ensure that any issues are resolved as quickly and as satisfactorily as possible, we do also have a responsibility to objectively assess the validity of any warranty claim, and to consider the interests of Valeport Limited in any actions taken.

M. Quartley

Matthew Quartley
Managing Director

Instrument Type **Modus SVS**

Serial Number(s) **33711**

Pressure Test **10 Bar**

Date of Despatch 14/12/2016

VALEPORT

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.

Calibration Certificate Number:	**47578**
Instrument Type:	**Modus SVS**
Instrument Serial Number:	**33747**
Calibrated By:	**L.Bicknell**
Date:	**15/12/2016**
Signed:	

Full details of the results from the calibration procedure applied to each fitted sensor are available, on request, via email. This summary certificate should be kept with the instrument.

Valeport Ltd | St Peter's Quay | Totnes | Devon | TQ9 5EW | UK
T: +44 (0) 1803 869292
E: sales@valeport.co.uk | www.valeport.co.uk

VALEPORT

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3) Reasonable wear and tear (as judged by Valeport) is not covered by warranty.
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M. Quartley

Matthew Quartley
Managing Director

Instrument Type Modus SVS ....

Serial Number(s) 33747 ....

Pressure Test 10 Bar...

Date of Despatch ....

Valeport Limited, St. Peter's Quay, Totnes, Devon, TQ9 5EW. U.K.
Tel: +44 (0)1803 869292 Fax: +44 (0)1803 869293
E-mail: sales@valeport.co.uk Web: www.valeport.co.uk

VAT No: GB 430 4453 84 Registered in England No: 1950444

Valeport Calibration Worksheet - 4008231B

Sound Velocity

Transducer Type, mm	50
Transducer Ser No	52296
PCB Type	400 round
PCB Part No	0400554
PCB Ser No	49899
SV Firmware Version	04007149B0
FPGA Firmware Version	0650714C
Module Number	12

As Received Spot Check

	SOS from unit	SOS from Standard	Error
Fresh	1412.611	1412.664	-0.053
Saline	#	#	#VALUE!
#VALUE!			

Temp °C90	SoS m/s	Measured ToF nsec*100	Calc ToF nsec*100	Meas-Calc ToF nsec	STAB	Half path mm	Total path mm
Low Temperature							
2.0905	1412.669	7444888	7078798	3660.90		50	100
2.0904	1412.669	7444885	7078801	3660.84		50	100
2.0905	1412.669	7444883	7078798	3660.85	STAB	50	100
#	#VALUE!	#	#VALUE!	#VALUE!		50	100
#	#VALUE!	#	#VALUE!	#VALUE!		50	100
High Temperature							
15.9072	1469.083	7173923	6806967	3669.56	STAB	50	100
15.9081	1469.086	7173916	6806953	3669.63		50	100
15.9078	1469.085	7173912	6806958	3669.54		50	100
#	#VALUE!	#	#VALUE!	#VALUE!		50	100
#	#VALUE!	#	#VALUE!	#VALUE!		50	100

Enter Last 6 bytes of characterisation string
-7
-2
1
3
4
5
Characterised OK

Return Signal Voltage
700mV

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
2.0905	1412.669	7444883	3.887600E+05	1412.669	0.000	±0.001	Pass
15.9072	1469.083	7173923	1.003214E+07	1469.083	0.000	±0.001	Pass

Stage 2: Enter calibration string

#024;12;1;15;0;0;0;0;1.003214E+07;3.887600E+05

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
15.9081	1469.086	1469.085	-0.001	±0.005	Pass

Stage 4: Reference Check

Reference SoS m/s	Sensor SoS m/s	Error SoS Reading-Actual m/s	Acceptable Error m/s	Pass/Fail
#	#	#VALUE!	±0.010	#VALUE!

Name:	L.Bicknell
Date:	15/12/2016
Signature:	LB

NOAA THOMAS JEFFERSON (S 222)
SENSOR ALIGNMENT & ORTHOGONAL COORDINATE SURVEY
JULY-AUGUST 2016

FINAL REPORT

September 1, 2016 - Rev "1"

Prepared By:
The **IMTEC** Group, Ltd.
19004 E Ringo Circle
Independence, MO 64057-1400 USA
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Industrial **M**easurement **T**echnology **E**ngineering **C**onsultants

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ELECTRONIC FILES TRANSMITTED WITH THIS REPORT

Raw Data-World.txt
Report Tables
- Kongsberg system.xlsx
- EM710TX system.xlxs
- IMU System.xlsx
- ORU System.xlsx

PROJECT OVERVIEW

Purpose

The purpose of this commentary is to summarize the procedures and analytical methods employed to perform the 3-D coordinate total station inspection that produced the data in this report for those unfamiliar with the equipment and process.

Dimensional data resulting from the inspection is included with the report.

General Comments

This report summarizes coordinate measurement data taken on the vessel NOAA Thomas Jefferson July 27 and 28, 2016 and August 22 thru 26, 2016. The vessel was located in a graving dock at US Coast Guard Yard, 2104 Hawkins Point Road, Baltimore, MD.

Coordinate measurements were taken to characterize the vessel and create the required reference coordinate system for reporting azimuth, pitch, roll and coordinate data.

Coordinate measurements were then taken to define elements and features according to the SOW MOA2-11(15) Dated December 8, 2015 and as requested by NOAA representatives in support of the EM710 Multi-Beam Sounding system transducer installation.

Locations of existing draft marks were measured and recorded.

3-D Coordinate Measurement Equipment

A Sokkia NET 1200 enhanced electronic total station operated through a notebook computer running New River Kinematics Spatial Analyzer™ measurement and analysis software was utilized. This system measures 3-D spherical coordinates by recording an azimuth and zenith angle simultaneously with the near infrared distance coaxial with the telescope line of sight for each observation. Spatial Analyzer measurement and analysis software converts the spherical coordinate data to a Cartesian coordinate system that can be defined by the user. Measurements are made to either adhesive or kinematic targets that have a retro-reflective target face.

Temporary "benchmarks" or reference points were placed throughout the dry-dock area and on the vessel as required to allow for re-locating the instrument to a new position or "Station" and tie all of the data to the common coordinate system for comparison.

The measuring system used for this final inspection report is one of several owned by The IMTEC Group, Ltd. The NET 1200 total station, S/N 110554 was calibrated, traceable to N.I.S.T. and in accordance with A.N.S.I. Z-540-1, at the Sokkia USA Factory Service Center November 17, 2015.

Reference Coordinate Systems

The following parameters were used to define the reference coordinate system for reporting the survey data per Kongsberg and NOAA representatives.

Kongsberg requested vessel coordinate system:

Origin: Top Dead Center (TDC) of the Inertial Measurement Unit (IMU):
X=0.000, Y=0.000, Z=0.000

Pitch and Azimuth:

Ten (10) Pairs of points were surveyed from approximately Frame 90 through Frame 10 on the Keel plate and then bisected to obtain a center point. These points were then projected onto the keel plane and used to construct a best fit line. A Best fit line faired through these points determined the ship system azimuth (X-Axis) and Pitch.

Roll: Six points were measured port/stbd, and fwd/aft and ~center port/stbd to determine the plane of the aft deck. This plane was used to establish roll.

Thus the vessel coordinate system is depicted as shown:

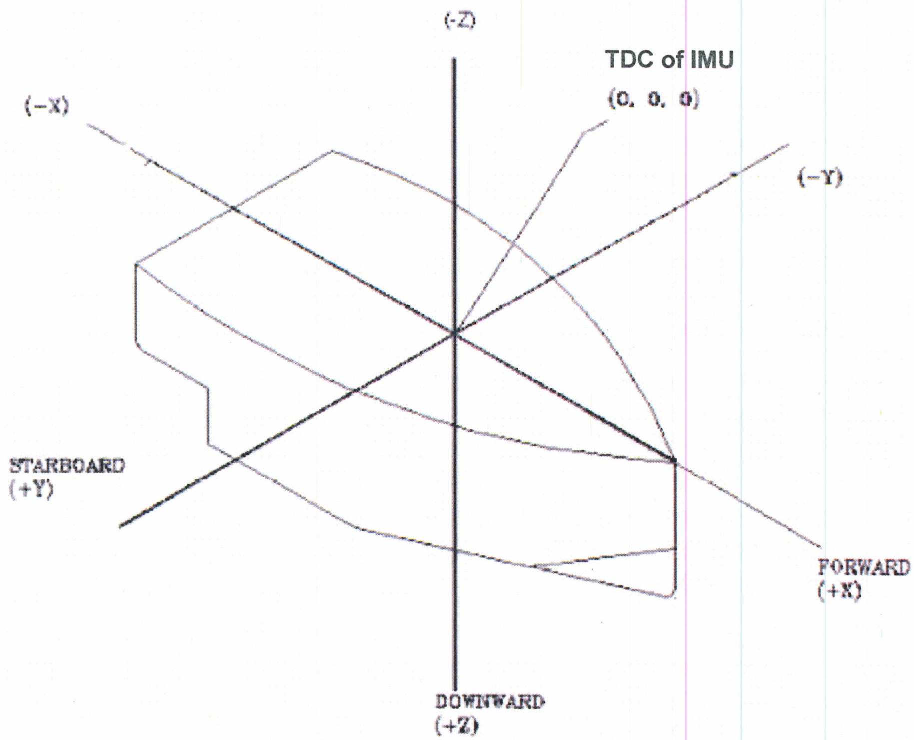


Figure 1 – Vessel Coordinate System

The first coordinate system requested by NOAA is defined as follows:

Origin:	Center of TX Transducer Frame: X=0.000, Y=0.000, Z=0.000
Pitch:	Plane of TX Transducer Frame.
Roll:	Plane of TX Transducer Frame.
X Axis:	Azimuth of TX Transducer Frame X axis Positive Forward.
Z Axis:	Normal to Plane of TX Transducer Frame axis Positive towards keel

The TX Frame therefore completely defines a vessel coordinate system.

The second coordinate system requested by NOAA is defined as follows:

Origin:	TDC target on IMU: X=0.000, Y=0.000, Z=0.000
Pitch:	Plane of IMU
Roll:	Plane of IMU
X Axis:	Azimuth of IMU X axis Positive Forward
Z Axis:	Normal to Plane of IMU axis Positive Towards keel

IMU therefore completely defines a vessel coordinate system.

The third coordinate system requested by NOAA is defined as follows:

Origin:	TDC target on ORU: X=0.000, Y=0.000, Z=0.000
Pitch:	Plane of ORU
Roll:	Plane of ORU
X Axis:	Azimuth of ORU X axis Positive Forward
Z Axis:	Normal to Plane of ORU axis positive Towards keel

ORU therefore completely defines a vessel coordinate system.

NOAA Representative requested that all survey data be presented in these coordinate systems including the draft marks.

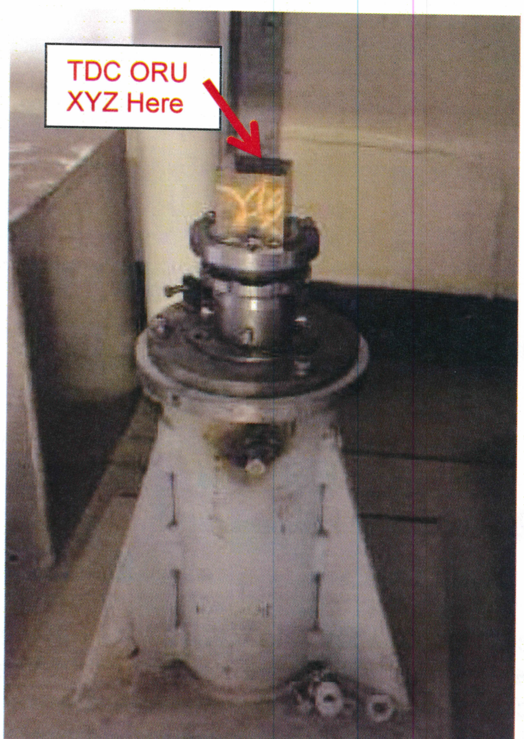


Figure 2- Optical Reference Unit (ORU)

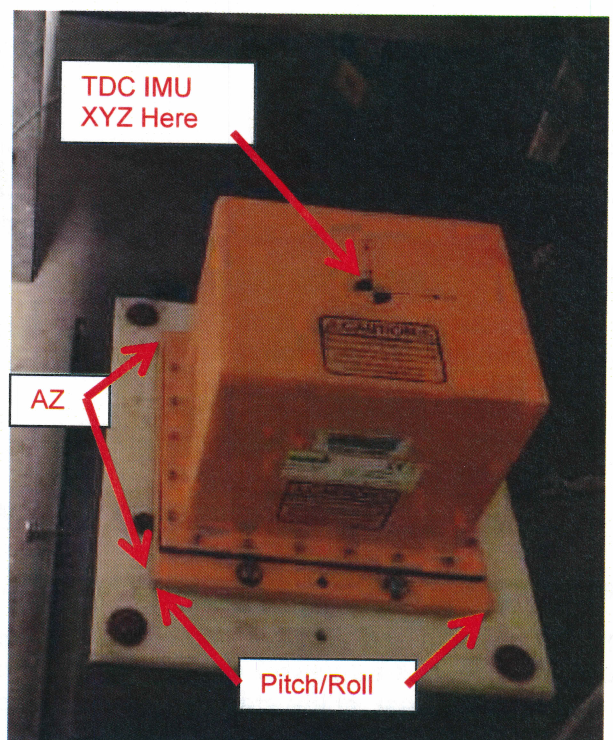


Figure 3- Inertial Measurement Unit (IMU)

Measurement Procedure

Adhesive targets with retro reflective target face were used throughout the survey as temporary benchmarks for relocating the instrument to new stations. Kinematic (a target with a known offset) retro reflective targets such as the RT-50M swivel targets were frequently used as a temporary benchmark. The Sokkia NET 1200 total station operated through a notebook computer running Spatial Analyzer™ industrial measurement software was used to measure the targets and record observations.

Gondola Installation

At the request of shipyard and NOAA personnel, IMTEC assisted with proper positioning of the gondola to within the azimuth, pitch and roll tolerances required by Kongsberg prior to welding.

EM 710TX, EM 710RX and EM2040 Transducer Frames

After the transducer frames were installed, data points were surveyed at each of the bolt locations to determine overall flatness. Shim values were provided to Kongsberg to meet the flatness requirement. After shims were added and bolts final torqued, the frames were again surveyed to document final flatness. Final location (X, Y, Z), pitch, roll and azimuth of the Kongsberg transducers frames with respect to the vessel coordinate system were determined.

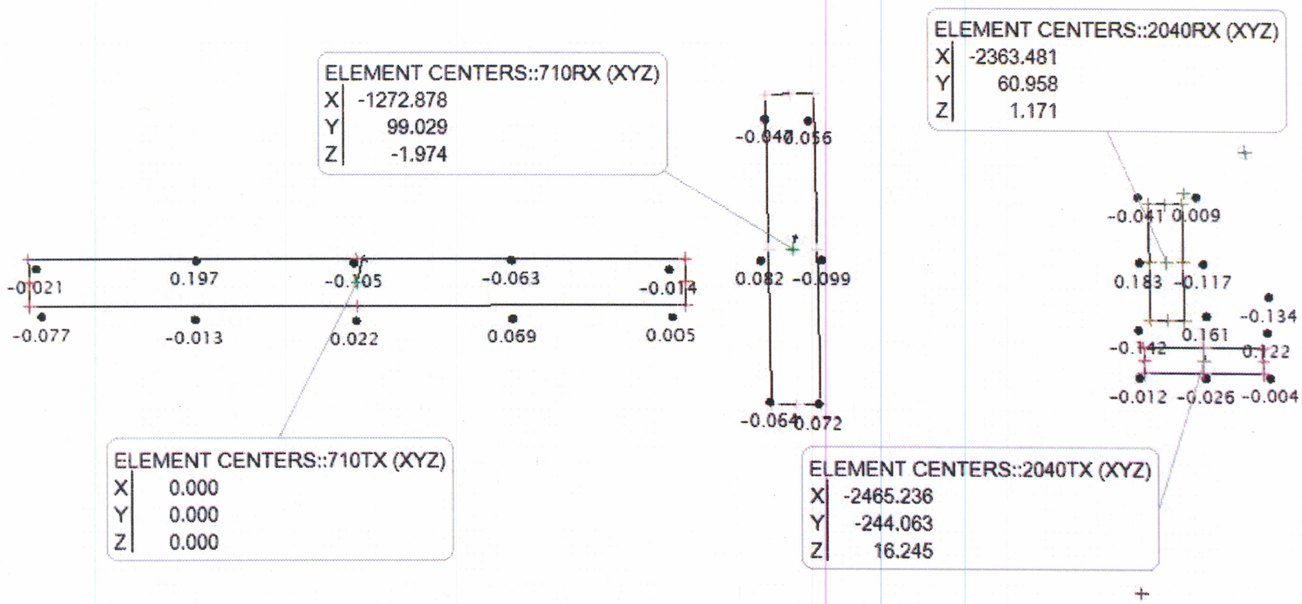


Figure 4-Flatness EM710 TX/RX and EM2040 TX/RX as Installed (mm)

Vessel Benchmarks and Navigation Elements

Existing benchmarks and elements were surveyed as part of this effort and values for each are reported in the requested vessel orthogonal coordinate system. Additional benchmarks were added at the top of mast, at the starboard side of aft deck and at the top of the pilot house.

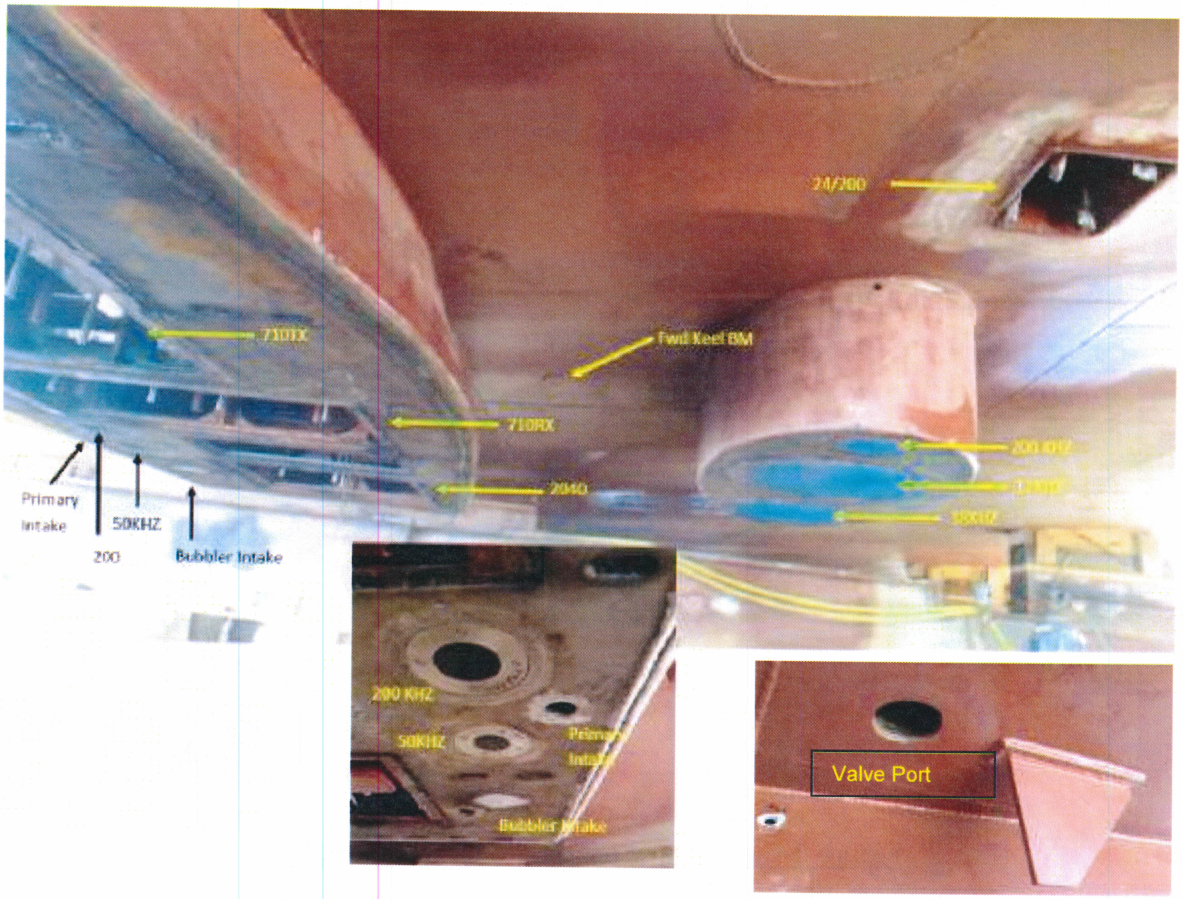


Figure 5-Elements at Bottom of Hull

Figure 6-Elements at Starboard side of Gondola

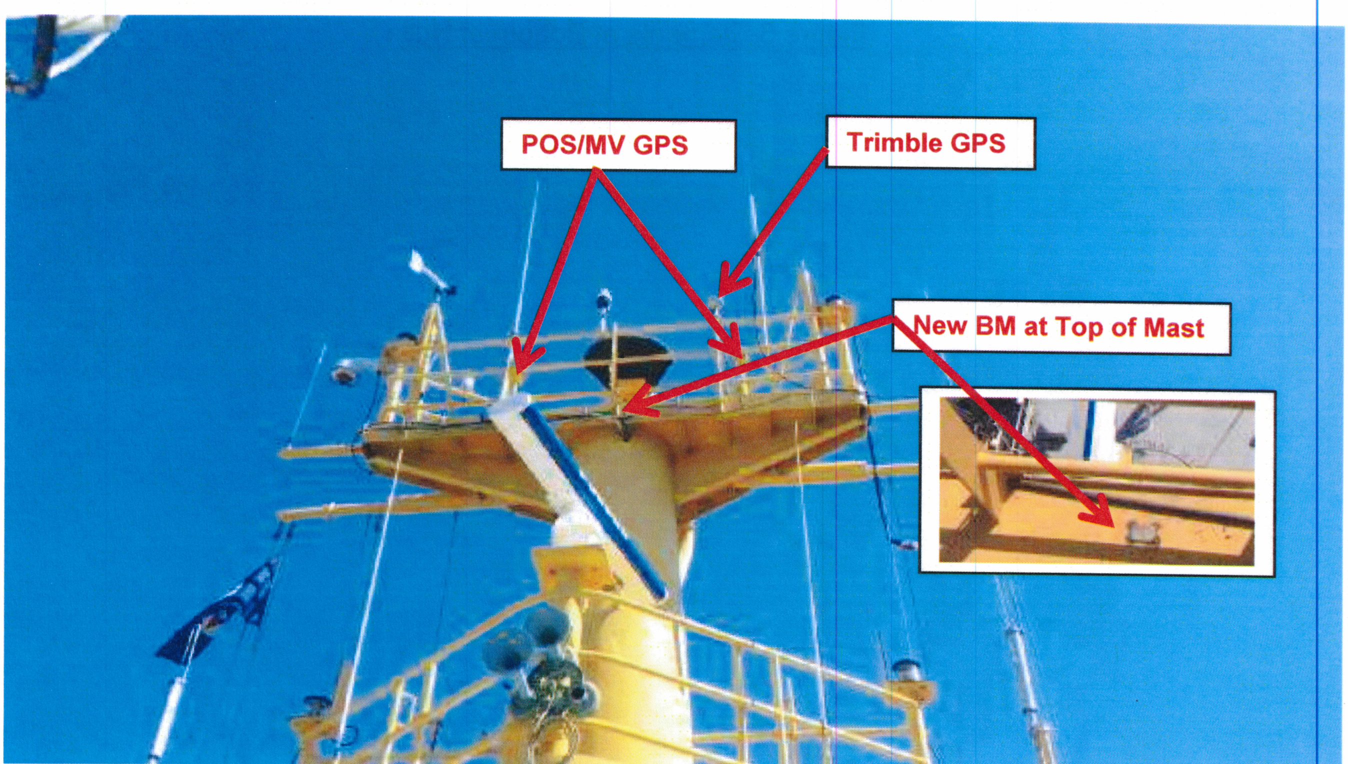


Figure 7- Mast Elements

Figure 8-GPS Antenna Elevations at bottom of Mount

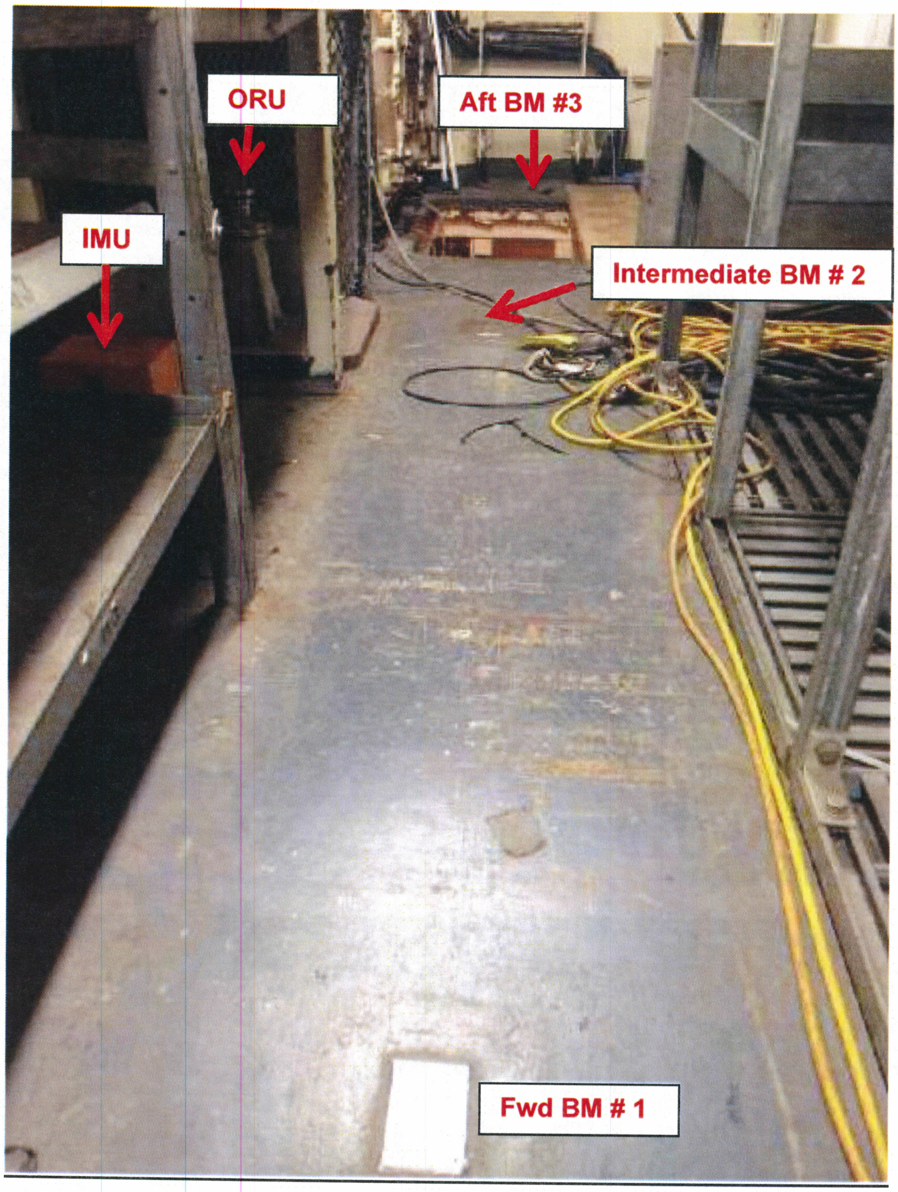


Figure 9 – Scientific Store Room

BM#1


BM#2

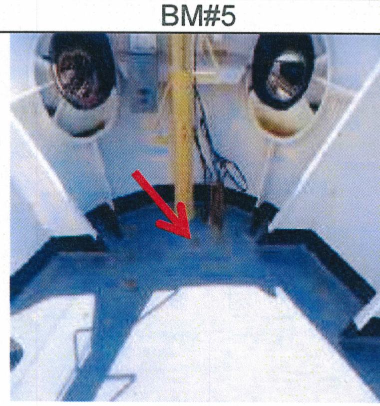

BM#3

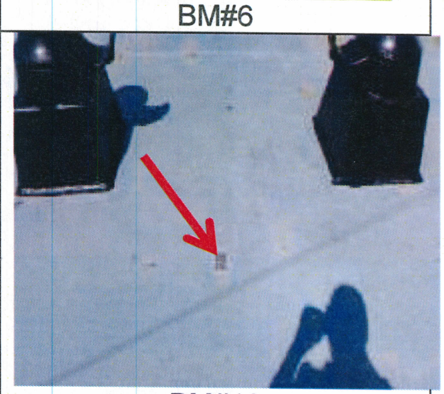

BM#4

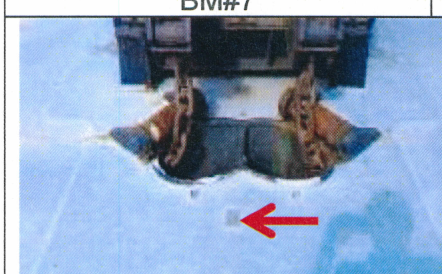

BM#5


BM#6

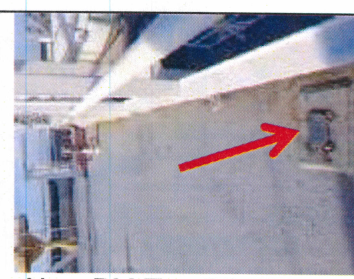

BM#7


BM#12


BM#13


BM#14


New Aft BM


New BM Top Pilot House

<u>Figure 10 – Bench Marks</u>

Measurement Precision and Uncertainty

Uncertainties are reported to be:

Point to Point, any element or target within the vessel survey to another element or feature in the survey

X, Y, & Z $\leq$ 1.5 mm

Region to Region, i.e., GPS antenna to EM710 RX/TX features:

X $\leq$ 2.0 mm
Y $\leq$ 2.0 mm
Z $\leq$ 2.0 mm

The angular measurement precision of the NET1200 is < 1 arc second in azimuth and zenith. There can be some error introduced by targeting. Random and systematic errors can be introduced by the working environment.

The expected angular precision of the survey is analyzed to be:

Azimuth, Pitch, Roll: $\leq$ 00° 00' 30"

PROJECT DATA

The required data is summarized in tabular form on the following pages. The units of measure for reporting are indicated on each table.

Table 1 reports the X, Y and Z, values for specified elements in units of meters and in the vessel coordinate system (Kongsberg System)

Table 2 reports the X, Y and Z, values for specified bench marks in units of meters and in the vessel coordinate system (Kongsberg system).

Table 3 reports the Azimuth, Pitch and Roll of specified elements in Kongsberg system.

Table 4 reports the summarized data for the draft mark survey and is presented with Feet as the unit of measure to correlate with the specific draft mark number. Draft mark elevations are reported above the best-fit keel as surveyed. The gondola projection is not reflected by any set of draft marks and projects 1.4 feet below the keel.

Appendix 1 is a copy of tables with the data presented with respect to the 1st coordinate system requested by NOAA EM710Tx Transducer Center as Origin and plane defining Pitch & Roll with azimuth clocked to X axis of transducer.

Appendix 2 is a copy of tables with the data presented with respect to the 2nd coordinate system requested by NOAA; IMU Center as Origin and plane IMU defining Pitch & Roll with azimuth clocked to X axis of IMU.

Appendix 3 is a copy of tables with the data presented with respect to the 3rd coordinate system requested by NOAA; ORU Center as Origin and ORU plane defining Pitch & Roll with azimuth clocked to X axis of ORU.

[3]TABLE 1-ELEMENT COORDINATES SHIP SYSTEM (m)			
ELEMENT	X	Y	Z
IMU (XYZ)	0.000	0.000	0.000
ORU (ORIGIN)	-0.843	-0.012	-0.132
710TX (XYZ)	-0.488	2.333	5.010
710RX (XYZ)	-1.760	2.434	5.008
2040RX (XYZ)	-2.851	2.397	5.012
2040TX (XYZ)	-2.953	2.092	5.027
[1]BUBBLER ORIFICE Z	-2.989	2.926	3.917
24/200 (XYZ)	-1.264	0.305	4.439
200KHZ_1 (XYZ)	-1.911	0.573	4.887
12KHZ_1 (XYZ)	-2.431	0.570	4.887
38KHZ (XYZ)	-3.084	0.567	4.890
3.5KHZ (XYZ)	-1.873	6.032	4.398
SEC INTAKE (XYZ)	-3.106	7.784	4.187
SRD500 (XYZ)	-3.066	5.183	4.594
VALVE PORT (XYZ)	-2.950	3.250	4.564
BUBBLER INTAKE (XYZ)	-3.090	2.733	5.010
50KHZ (XYZ)	-2.611	2.881	5.012
PRIMARY INTAKE (XYZ)	-2.487	3.013	5.010
200KHZ_2 (XYZ)	-2.344	2.882	5.012
12KHZ_2 (XYZ)	-1.272	4.555	4.438
[2]TRIMBLE GPS	-9.040	1.575	-22.214
[2]POS MV PORT	-9.924	1.373	-22.344
[2]POS MV STBD	-9.913	3.583	-22.335

(1) Bubbler Orfice Z (X and Y approx)

(2) Z at Base, see Figure 8

(3) Kongsberg System Ships Orthogonal system on TDC IMU

TABLE 2- BENCH MARKS SHIP SYSTEM (m)			
BENCH MARK	X	Y	Z
SCI STORE FWD #1	1.027	-0.567	0.287
SCI STORE INTR #2	-1.132	-0.577	0.291
SCI STORE AFT #3	-3.294	-0.589	0.289
FWD KEEL #4	-2.787	1.515	4.555
AFT KEEL #5	-16.152	1.51	4.557
MAIN PASS #6	-6.435	3.337	-2.517
DC PASS #7	-16.141	3.287	-2.51
BOW FWD #12	21.026	2.535	-5.183
BOW MID #13	17.187	2.516	-5.175
BOW AFT#14	14.643	2.512	-5.192
PILOT HOUSE (NEW)	-7.568	5.304	-12.92
TOP MAST (NEW)	-9.151	2.942	-20.999
STBD AFT END (New)	-39.506	7.544	-3.079

TABLE 3 - HEADING, PITCH. ROLL OF ELEMENTS (decimal dgrees)						
ELEMENT	HEADING		PITCH		ROLL	
	VALUE	DIRECTION	VALUE	DIRECTION	VALUE	DIRECTION
SHIP SYSTEM	0.00000	-	0.00000	-	0.00000	-
IMU	0.64167	STBD	0.07198	BOW DOWN	0.24375	STBD DOWN
ORU	0.04400	PORT	0.08500	BOW DOWN	0.07779	STBD DOWN
EM710 TX	0.05539	PORT	0.01315	BOW UP	0.00927	STBD UP
EM710RX	0.21797	STBD	0.09935	BOW UP	0.06457	STBD DOWN
EM2040TX	0.1466	STBD	0.19035	BOW UP	0.08625	STBD UP
EM2040RX	0.13963	STBD	0.20005	BOW UP	0.17817	STBD UP

TABLE 4 - DRAFT MARKS (elev above keel, feet)							
PORT				STARBOARD			
DRAFT MARK	ELEVATION AS SURVEYED			DRAFT MARK	ELEVATION AS SURVEYED		
	FWD	MID	AFT		FWD	MID	AFT
12	-	-	-	12	-	11.9	-
13	12.9	-	-	13	12.9	-	-
14	13.9	14.0	-	14	13.9	13.9	-
15	15.0	15.0	15.1	15	15.0	14.9	15.1
16	16.0	16.0	16.1	16	16.0	15.9	16.0
17	16.9	17.0	17.1	17	16.9	16.9	17.1

Certificate of Calibration

Item No / Model: NET 1200

Manufacturer: SOKKIA

Serial No: 110554 Certificate Number: 60997

This certifies that the above instrument has been inspected and calibrated by the Sokkia Corporation Service Department. This inspection was performed using the procedures set forth in the NET SERIES INSTRUMENT CALIBRATION AND CERTIFICATION MANUAL (August 18, 2005 Rev. 8). At the time of completion of this service, Sokkia Corporation certifies that the above stated instrument meets or exceeds all factory specifications and tolerances for instrument parameters and performance of this instrument model. The certification is effective for a 12 month period from the calibration date shown below.

All distance measurement parameters were tested and adjusted using factory calibration jigs and with the 10 Meter Calibration Rail whose accuracy is traceable to the National Institute of Standards and Technology (N.I.S.T) via Mutual Recognition Agreement. All angle measurement parameters were tested with a NIST traceable optical collimation system, using accepted collimation and adjustment procedures.

The quality system addresses and conforms to ANSI/NCSL Z540-1-1994 and ISO/IEC 17025-1999 (and, as a result ISO 9001-1994 or ISO 9002-1994)

This certificate shall not be reproduced except in full, without the written approval of Sokkia Corporation

Customer Name: IMTEC GROUP, Ltd

Customer Address: 19004 E. RINGO CIR.

Customer City/State/Zip: INDEPENDENCE, MO 64057

See individual sets of data for temperature and pressure

Date Calibrated: 11/17/2015 Date Recalibration Due: 11/17/2016

Signed: Al Edwin Date: 11/17/2015

Yes	No	
	X	Is this a new instrument?

Answer the following questions only if the above answer is "No".

	X	Is this the first NIST calibration we have performed on this instrument?
X		Were the calibration seals intact when the instrument was received?
	X	Were the initial collimation inspection results within tolerance?
	X	Were the initial EDM inspection results within tolerance?
	X	Was the instrument damaged/defective and unable to have an initial inspection?
	X	Corrective action recommended?

* See page 2 for a list of primary standards

Page 1 of 2

Appendix 1 – NOAA Requested System wrt 710TX

(3) A1 TABLE 1-ELEMENT COORDINATES 710TX SYSTEM (m)			
ELEMENT	X	Y	Z
IMU (XYZ)	0.491	-2.332	-5.010
ORU (ORIGIN)	-0.351	-2.345	-5.143
710TX (XYZ)	0.000	0.000	0.000
710RX (XYZ)	-1.273	0.099	-0.002
2040RX (XYZ)	-2.363	0.061	0.001
2040TX (XYZ)	-2.465	-0.244	0.016
(1)BUBBLER ORIFICE Z	-2.501	0.590	-1.094
24/200 (XYZ)	-0.774	-2.029	-0.571
200KHZ_1 (XYZ)	-1.421	-1.762	-0.124
12KHZ_1 (XYZ)	-1.942	-1.765	-0.123
38KHZ (XYZ)	-2.594	-1.769	-0.121
3.5KHZ (XYZ)	-1.389	3.698	-0.612
SEC INTAKE (XYZ)	-2.623	5.448	-0.823
SRD500 (XYZ)	-2.581	2.847	-0.417
VALVE PORT (XYZ)	-2.463	0.914	-0.447
BUBBLER INTAKE (XYZ)	-2.603	0.397	-0.001
50KHZ (XYZ)	-2.124	0.545	0.002
PRIMARY INTAKE (XYZ)	-2.000	0.678	0.000
200KHZ_2 (XYZ)	-1.857	0.546	0.002
12KHZ_2 (XYZ)	-0.786	2.221	-0.572
(2)TRIMBLE GPS	-8.545	-0.762	-27.226
(2)POS MV PORT	-9.429	-0.965	-27.357
(2)POS MV STBD	-9.420	1.245	-27.347

(1) Bubbler Orfice Z (X and Y approx)

(2) Z at Base, see Figure 8

(3) NOAA Requested System 1 Orthogonal system on 710TX

A1 TABLE 2- BENCH MARKS 710TX SYSTEM (m)			
BENCH MARK	X	Y	Z
SCI STORE FWD #1	1.519	-2.898	-4.723
SCI STORE INTR #2	-0.64	-2.911	-4.72
SCI STORE AFT #3	-2.803	-2.924	-4.722
FWD KEEL #4	-2.299	-0.82	-0.456
AFT KEEL #5	-15.663	-0.838	-0.457
MAIN PASS #6	-5.946	1	-7.528
DC PASS #7	-15.652	0.94	-7.523
BOW FWD #12	21.516	0.224	-10.189
BOW MID #13	17.677	0.201	-10.181
BOW AFT#14	15.133	0.195	-10.198
PILOT HOUSE (NEW)	-7.079	2.967	-17.931
TOP MAST (NEW)	-8.658	0.604	-26.011
STBD AFT END (New)	-39.022	5.174	-8.097

A1 -TABLE 3 - HEADING, PITCH. ROLL OF ELEMENTS 710 TX SYSTEM (decimal dgrees)						
ELEMENT	HEADING		PITCH		ROLL	
	VALUE	DIRECTION	VALUE	DIRECTION	VALUE	DIRECTION
IMU	0.69705	STBD	0.08490	BOW DOWN	0.25310	STBD DOWN
ORU	0.01138	STBD	0.09813	BOW DOWN	0.08710	STBD DOWN
EM710 TX	0.00000	-	0.00000	-	0.00000	-
EM710RX	0.27337	STBD	0.08627	BOW UP	0.07377	STBD DOWN
EM2040TX	0.20202	STBD	0.17713	BOW UP	0.07714	STBD UP
EM2040RX	0.19498	STBD	0.18675	BOW UP	0.16907	STBD UP

Appendix 2 – NOAA Requested System wrt IMU

(3) A2 TABLE 1-ELEMENT COORDINATES IMU SYSTEM (m)			
ELEMENT	X	Y	Z
(4)IMU (XYZ)	0	0	0
ORU (ORIGIN)	-0.843	-0.003	-0.131
710TX (XYZ)	-0.455	2.36	5.001
710RX (XYZ)	-1.727	2.474	5
2040RX (XYZ)	-2.818	2.45	5.005
2040TX (XYZ)	-2.923	2.146	5.022
(1)BUBBLER ORIFICE Z	-2.951	2.975	3.908
24/200 (XYZ)	-1.255	0.338	4.44
200KHZ_1 (XYZ)	-1.898	0.615	4.887
12KHZ_1 (XYZ)	-2.418	0.618	4.888
38KHZ (XYZ)	-3.071	0.623	4.892
3.5KHZ (XYZ)	-1.8	6.071	4.375
SEC INTAKE (XYZ)	-3.013	7.836	4.157
SRD500 (XYZ)	-3.002	5.237	4.575
VALVE PORT (XYZ)	-2.908	3.302	4.554
BUBBLER INTAKE (XYZ)	-3.053	2.789	5.002
50KHZ (XYZ)	-2.572	2.931	5.003
PRIMARY INTAKE (XYZ)	-2.447	3.062	5
200KHZ_2 (XYZ)	-2.305	2.929	5.003
12KHZ_2 (XYZ)	-1.215	4.588	4.42
(2)TRIMBLE GPS	-9.051	1.582	-22.209
(2)POS MV PORT	-9.937	1.389	-22.338
(2)POS MV STBD	-9.901	3.599	-22.337

(1) Bubbler Orfice Z (X and Y approx)

(2) Z at Base, see Figure 8

(3) NOAA Requested System 2 Orthogonal system on IMU

(4)TDC IMU is 4.6 meters above Keel

A2 TABLE 2- BENCH MARKS IMU SYSTEM (m)			
BENCH MARK	X	Y	Z
SCI STORE FWD #1	1.021	-0.577	0.289
SCI STORE INTR #2	-1.138	-0.563	0.294
SCI STORE AFT #3	-3.300	-0.550	0.296
FWD KEEL #4	-2.764	1.566	4.552
AFT KEEL #5	-16.128	1.710	4.571
MAIN PASS #6	-6.400	3.399	-2.523
DC PASS #7	-16.106	3.457	-2.503
BOW FWD #12	21.046	2.277	-5.221
BOW MID #13	17.207	2.301	-5.207
BOW AFT#14	14.664	2.326	-5.221
PILOT HOUSE (NEW)	-7.525	5.334	-12.932
TOP MAST (NEW)	-9.145	2.955	-21.000
STBD AFT END (New)	-39.423	7.973	-3.061

A2 -TABLE 3 - HEADING, PITCH. ROLL OF ELEMENTS (decimal dgrees IMU System)						
ELEMENT	HEADING		PITCH		ROLL	
	VALUE	DIRECTION	VALUE	DIRECTION	VALUE	DIRECTION
IMU	0.00000	-	0.00000	-	0.00000	-
ORU	0.68556	PORT	0.01122	BOW DOWN	0.16615	STBD UP
EM710 TX	0.69738	PORT	0.08796	BOW UP	0.25206	STBD UP
EM710RX	0.42371	PORT	0.17333	BOW UP	0.17725	STBD UP
EM2040TX	0.49611	PORT	0.26602	BOW UP	0.32704	STBD UP
EM2040RX	0.50177	PORT	0.27675	BOW UP	0.41885	STBD UP

Appendix 3 – NOAA Requested Coordinates wrt ORU

(3) A3 TABLE 1-ELEMENT COORDINATES ORU SYSTEM (m)			
ELEMENT	X	Y	Z
(4)IMU (XYZ)	0.843	0.013	0.131
ORU (ORIGIN)	0.000	0.000	0.000
710TX (XYZ)	0.361	2.353	5.139
710RX (XYZ)	-0.912	2.452	5.139
2040RX (XYZ)	-2.003	2.414	5.144
2040TX (XYZ)	-2.105	2.109	5.160
(1)BUBBLER ORIFICE Z	-2.142	2.941	4.048
24/200 (XYZ)	-0.415	0.322	4.572
200KHZ_1 (XYZ)	-1.061	0.591	5.020
12KHZ_1 (XYZ)	-1.582	0.587	5.021
38KHZ (XYZ)	-2.234	0.584	5.025
3.5KHZ (XYZ)	-1.029	6.049	4.524
SEC INTAKE (XYZ)	-2.263	7.800	4.312
SRD500 (XYZ)	-2.221	5.200	4.722
VALVE PORT (XYZ)	-2.103	3.266	4.695
BUBBLER INTAKE (XYZ)	-2.242	2.750	5.142
50KHZ (XYZ)	-1.763	2.898	5.143
PRIMARY INTAKE (XYZ)	-1.639	3.031	5.141
200KHZ_2 (XYZ)	-1.496	2.899	5.143
12KHZ_2 (XYZ)	-0.426	4.573	4.565
(2)TRIMBLE GPS	-8.231	1.550	-22.071
(2)POS MV PORT	-9.115	1.348	-22.201
(2)POS MV STBD	-9.106	3.558	-22.194

(1) Bubbler Orfice Z (X and Y approx)
(2) Z at Base, see Figure 8
(3) NOAA Requested System 3 Orthogonal system on ORU
(4)TDC ORU is 4.7 meters above Keel

A3 TABLE 2- BENCH MARKS ORU SYSTEM (m)			
BENCH MARK	X	Y	Z
SCI STORE FWD #1	1.871	-0.553	0.418
SCI STORE INTR #2	-0.288	-0.565	0.424
SCI STORE AFT #3	-2.451	-0.578	0.426
FWD KEEL #4	-1.939	1.532	4.688
AFT KEEL #5	-15.304	1.517	4.710
MAIN PASS #6	-5.598	3.342	-2.381
DC PASS #7	-15.304	3.284	-2.359
BOW FWD #12	21.859	2.556	-5.087
BOW MID #13	18.020	2.535	-5.072
BOW AFT#14	15.476	2.529	-5.086
PILOT HOUSE (NEW)	-6.749	5.294	-12.784
TOP MAST (NEW)	-8.342	2.919	-20.858
STBD AFT END (New)	-38.674	7.522	-2.900

A3 -TABLE 3 - HEADING, PITCH. ROLL OF ELEMENTS (decimal dgrees ORU System)						
ELEMENT	HEADING		PITCH		ROLL	
	VALUE	DIRECTION	VALUE	DIRECTION	VALUE	DIRECTION
IMU	0.68529	STBD	0.01321	BOW UP	0.16601	STBD DOWN
ORU	0.00000	-	0.00000	-	0.00000	-
EM710 TX	0.01276	PORT	0.09815	BOW UP	0.08708	STBD UP
EM710RX	0.26191	STBD	0.18441	BOW UP	0.01330	STBD UP
EM2040TX	0.18694	STBD	0.27532	BOW UP	0.16419	STBD UP
EM2040RX	0.18391	STBD	0.28496	BOW UP	0.25613	STBD UP
24/200 kHz	-	-	0.47762	BOW UP	0.02678	STBD DOWN
12kHz-2	-	-	0.36558	BOW UP	0.23158	STBD UP
12kHz-1	-	-	0.23913	BOW UP	0.09000	STBD UP
200kHz-1	-	-	0.13427	BOW UP	0.46860	STBD UP
200kHz-2	-	-	0.08863	BOW UP	0.32335	STBD UP
38kHz	-	-	0.32417	BOW UP	0.01594	STBD DOWN
50kHz	-	-	0.34673	BOW UP	0.43530	STBD UP
SRD500	-	-	0.54483	BOW UP	0.71415	STBD DOWN
3.5 kHz	-	-	0.17175	BOW UP	0.04851	STBD DOWN
ADCP(1)	-	-	-	-	-	-

(1) ADCP not installed at time of survey

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

Thomas Jefferson Launch 2903
Component Spatial Relationship Survey
Field Report

Kevin Jordan
May 1, 2017

PURPOSE

The intention of this survey was to accurately position the POS/MV IMU, GPS Antennas, Receiver and Transmitter, Side Scan Reference Marks and bench marks on TJ launch 2903.

PROJECT DETAILS

This survey was conducted on May 1, 2017 at NOAA's Marine Operations Center in Norfolk, VA . The boat was on jack stands and leveled. The temperature was around 70 degrees and winds 10-15 mph.

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. 5.7.2

ForeSight DXM Ver. 3.2.2 was used for post processing.

PERSONNEL

Kevin Jordan	NOAA/NOS/NGS/Field Operations Branch	757-441-5467
Jim Harrington	NOAA/NOS/NGS/Field Operations Branch	757-441-5496
Ryan Hippenstiel	NOAA/NOS/NGS/Field Operations Branch	757-441-6595

Temporary Control

A network of temporary control was established on the lot consisting or two marks set on solid ground about 60 meters apart. These points were named TP 1 and TP 2. The majority of observations were performed using one setup on TP 1. TP 2 was utilized to setup the instrument and observe two additional points on the hull of the boat.

OBSERVED POINTS

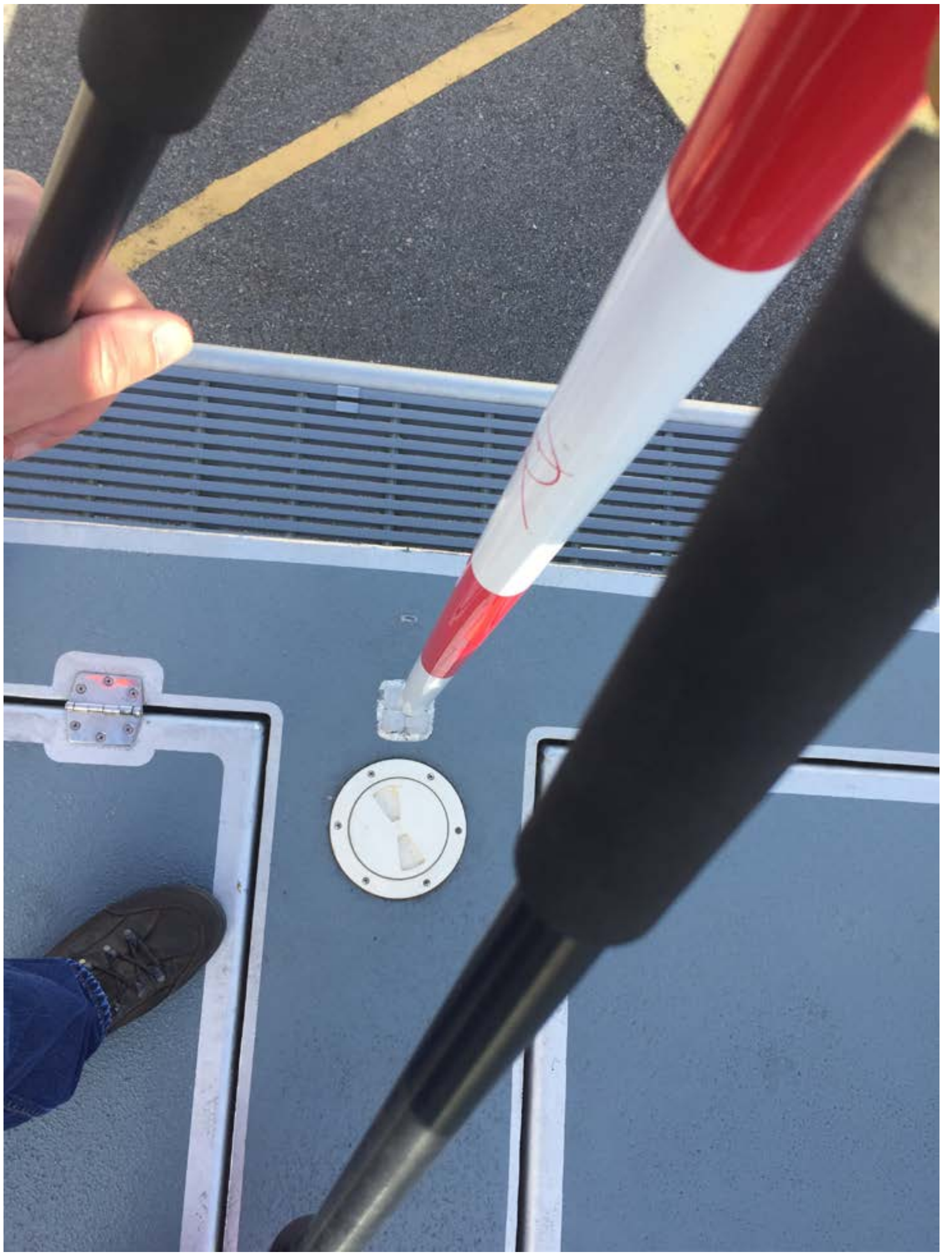
IMU

CL 1

CL 2

CL 3

CL 4



BM PORT 3

BM PORT 2

BM PORT 1

BM STAR 3

BM STAR 2

BM STAR 1

GPS PORT ARP

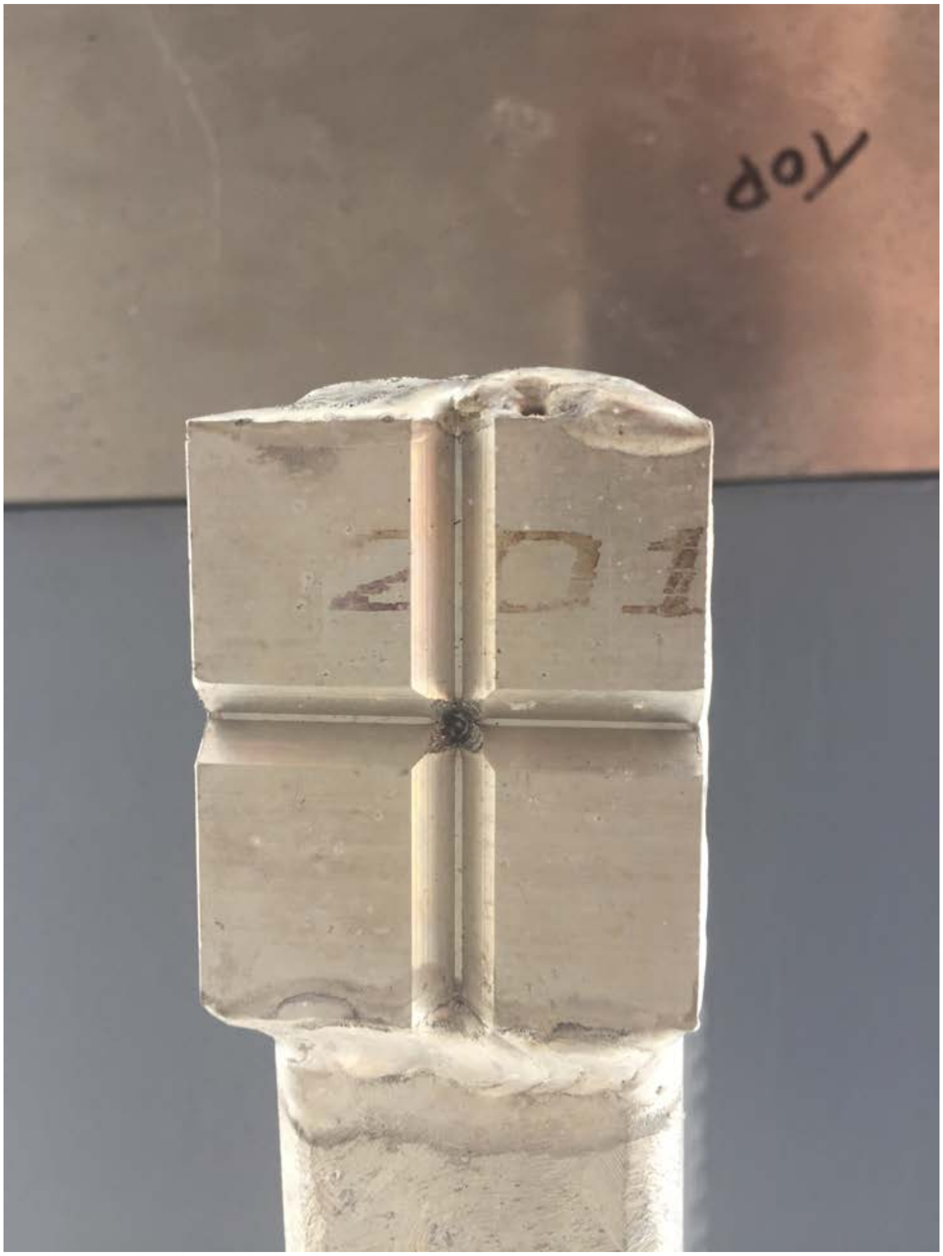
GPS STAR ARP

SIDE SCAN TOW POINT RM

RECEIVER

TRANSMITTER

KEEL BM FWD

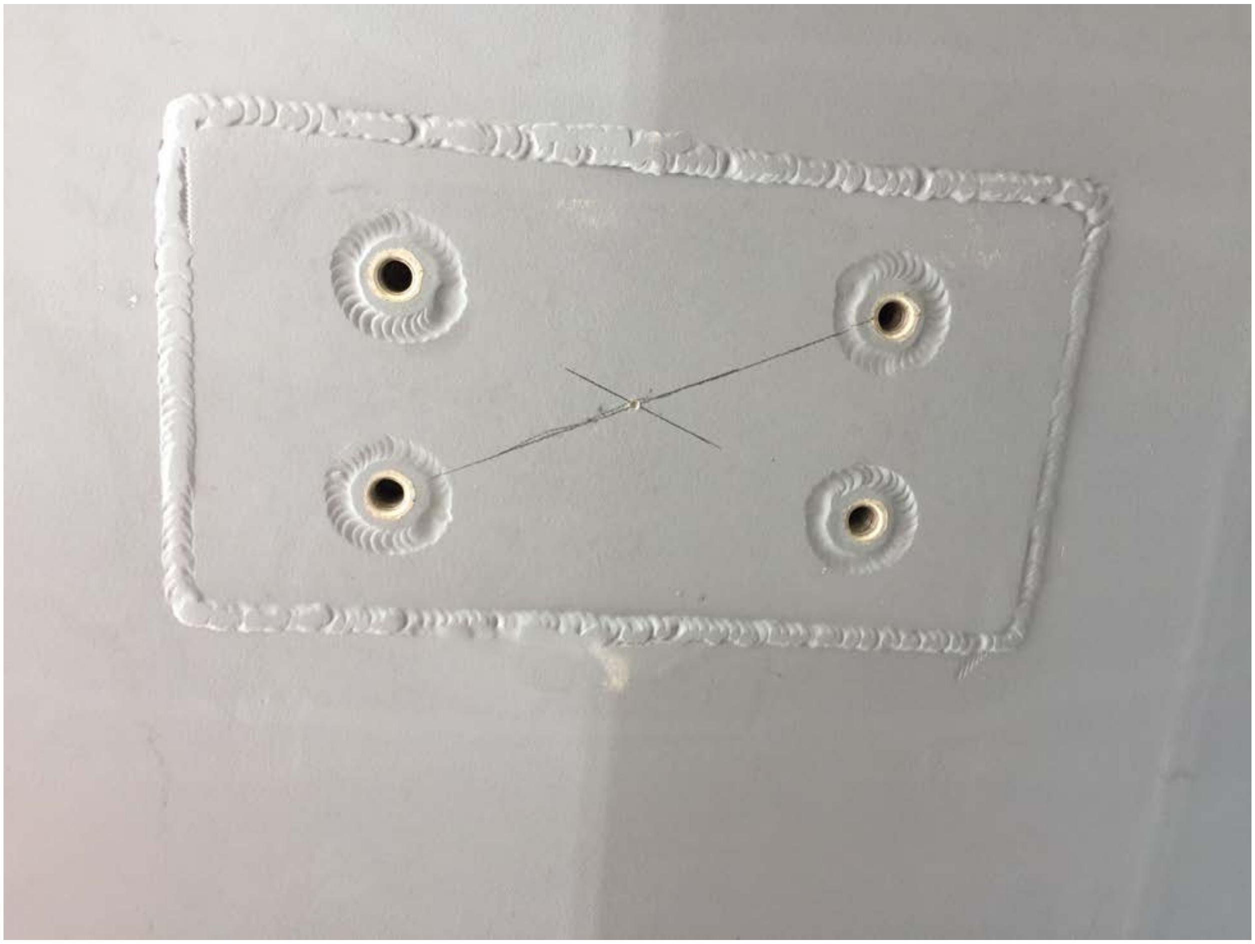


KEEL BM AFT

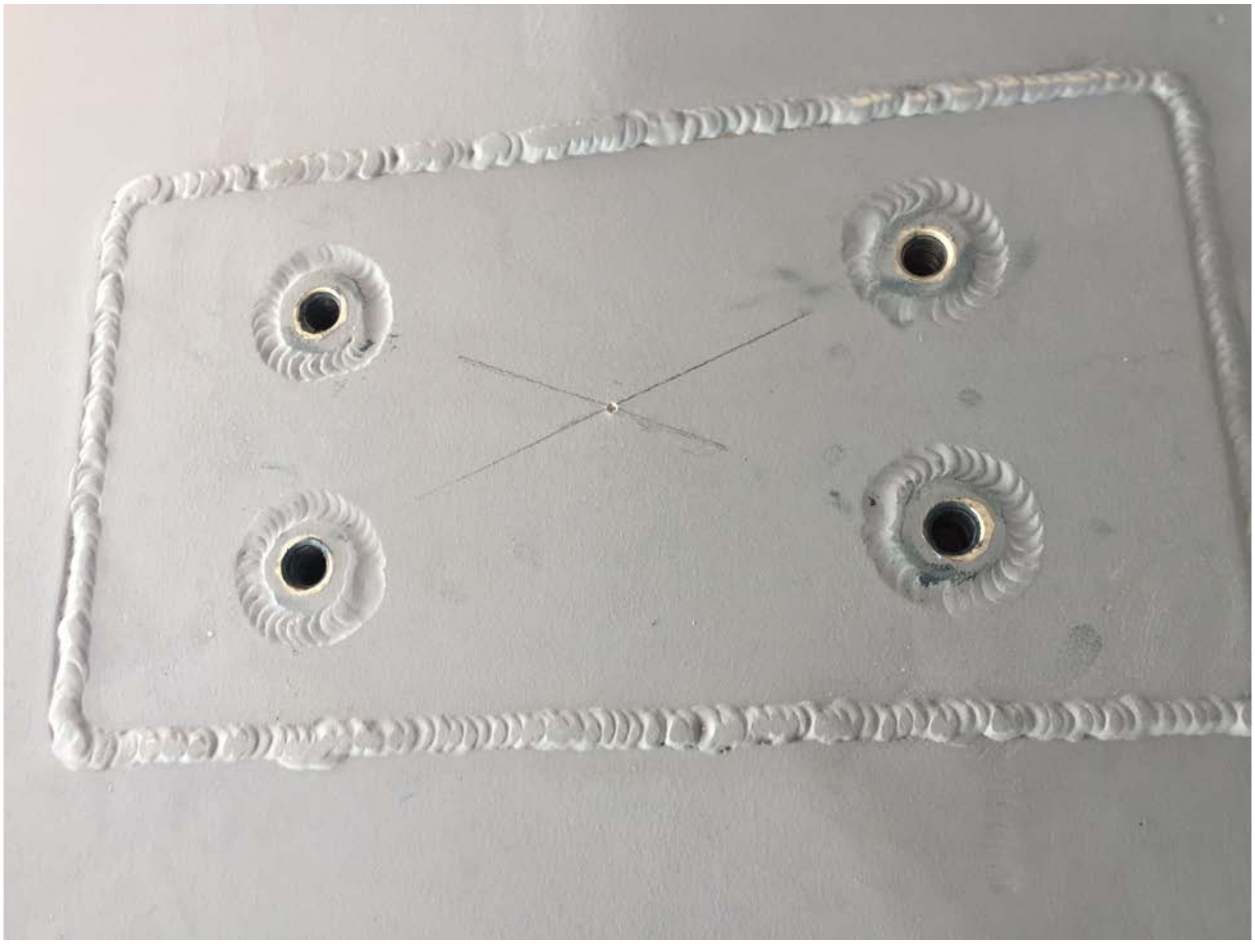
PORT SIDE SCAN HARD POINT FWD

PORT SIDE SCAN HARD POINT AFT

STAR SIDE SCAN HARD POINT FWD



STAR SIDE SCAN HARD POINT AFT



POST PROCESSING

The collected points were surveyed in an assumed coordinate system and needed to be translated to the point “IMU” as X=0, Y=0, Z=0. The azimuth from CL 4 to CL 1 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.

Transmitter center

The transmitter center was determined by measuring the length and width of the face (fwd to aft, port to starboard) and splitting the difference of the measurement. A temporary mark was placed on a piece of masking tape and measured.

Side Scan Tow Point Reference Mark

A reference mark for the Side Scan Sonar was established as part of this survey. The point of measurement can be described as a “.” punch mark below the port-facing middle bracket on the side-scan arm.

Final Coordinate List

An excel spreadsheet labeled TJ_2903.xlsx is included with the project submission. Below is a report of the final coordinate listing.

2903 Boat Survey 2017

NAME	**X (METERS)**	**Y (METERS)**	**Z (METERS)**
IMU	0.000	0.000	0.000
CL1	3.591	0.002	-1.322
CL3	-0.212	0.012	-0.657
CL2	-0.145	0.029	-2.651
CL4	-4.020	0.002	-0.742
BM PORT 3	-1.581	-0.618	-2.671
BM PORT 2	-0.702	-0.467	-3.043
BM PORT 1	0.174	-1.424	-1.069
BM STAR 3	-1.581	0.692	-2.667
BM STAR 2	-0.698	0.509	-3.046
BM STAR 1	0.170	1.440	-1.052
GPS PORT ARP	-0.693	-0.710	-3.572
GPS STAR ARP	-0.680	0.746	-3.579
SIDE SCAN TOW POINT RM	-5.307	-0.015	-3.121
RECEIVER	0.263	0.000	0.530
TRANSMITTER	0.044	-0.005	0.532
KEEL BM FWD	0.455	0.001	0.632
KEEL BM AFT	-0.577	0.002	0.716
PORT SIDE SCAN HARD POINT FWD	1.102	-0.561	0.303
PORT SIDE SCAN HARD POINT AFT	0.188	-0.566	0.307
STAR SIDE SCAN HARD POINT FWD	1.105	0.554	0.322
STAR SIDE SCAN HARD POINT AFT	0.195	0.572	0.319

***NOTE Z VALUES ARE POSITIVE DOWNWARD**

SURVEY CLOSURE

The majority of points were established by occupying a temporary mark (TP 1) established on solid ground about 11 meters behind the stern of the boat. Throughout the survey, Horizontal and Vertical checks were made to the 2nd temporary point that was established on the lot (TP 2). At the end of the observations, a check point was collected and an inverse was computed.

TP 2

Δ X = 0.001 m

Δ Y = 0.003 m

Δ Z = 0.005 m

A second setup was required to collect two additional points. The instrument was setup on TP 2 and backsight TP 1. The initial survey setup checked TP 1 by:

CK TP 1

Δ X = 0.001 m

Δ Y = 0.000 m

Δ Z = 0.003 m

Following the collection of the additional points, a final check to TP 1 was performed and closure was:

CK TP 1

Δ X = 0.001 m

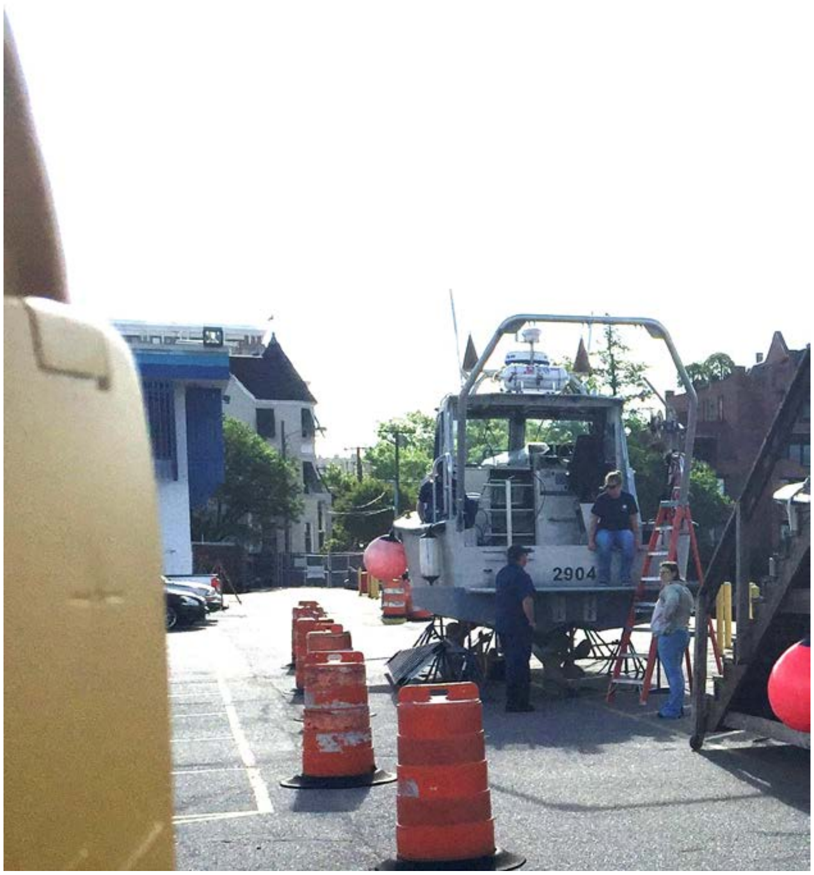
Δ Y = 0.001 m

Δ Z = 0.001 m

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

Thomas Jefferson Launch 2904
Component Spatial Relationship Survey
Field Report

Kevin Jordan
May 1, 2017



PURPOSE

The intention of this survey was to accurately position the POS/MV IMU, GPS Antennas, Receiver and Transmitter, Side Scan Reference Marks and bench marks on TJ launch 2904.

PROJECT DETAILS

This survey was conducted on May 1, 2017 at NOAA's Marine Operations Center in Norfolk, VA . The boat was on jack stands and leveled. The temperature was around 70 degrees and winds 10-15 mph.

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. 5.7.2

ForeSight DXM Ver. 3.2.2 was used for post processing.

PERSONNEL

Kevin Jordan	NOAA/NOS/NGS/Field Operations Branch	757-441-5467
Jim Harrington	NOAA/NOS/NGS/Field Operations Branch	757-441-5496
Ryan Hippenstiel	NOAA/NOS/NGS/Field Operations Branch	757-441-6595

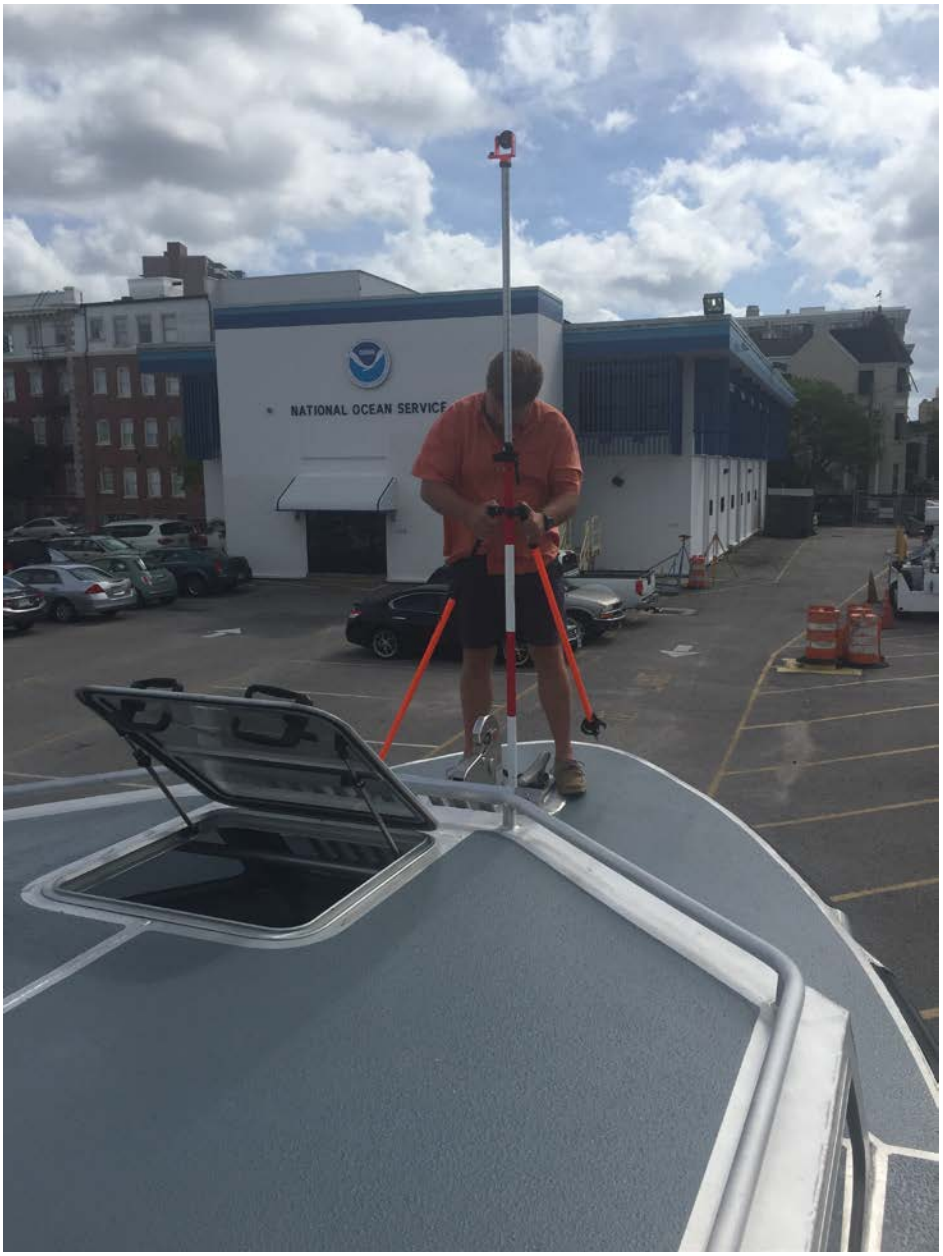
Temporary Control

A network of temporary control was established on the lot consisting or two marks set on solid ground about 60 meters apart. These points were named TP 1 and TP 2. The majority of observations were performed using one setup on TP 1. TP 2 was utilized to setup the instrument and observe two additional points on the hull of the boat.

OBSERVED POINTS

IMU

CL 1



CL 2

CL 3

CL 4

BM PORT 3

BM PORT 2

BM PORT 1

BM STAR 3

BM STAR 2

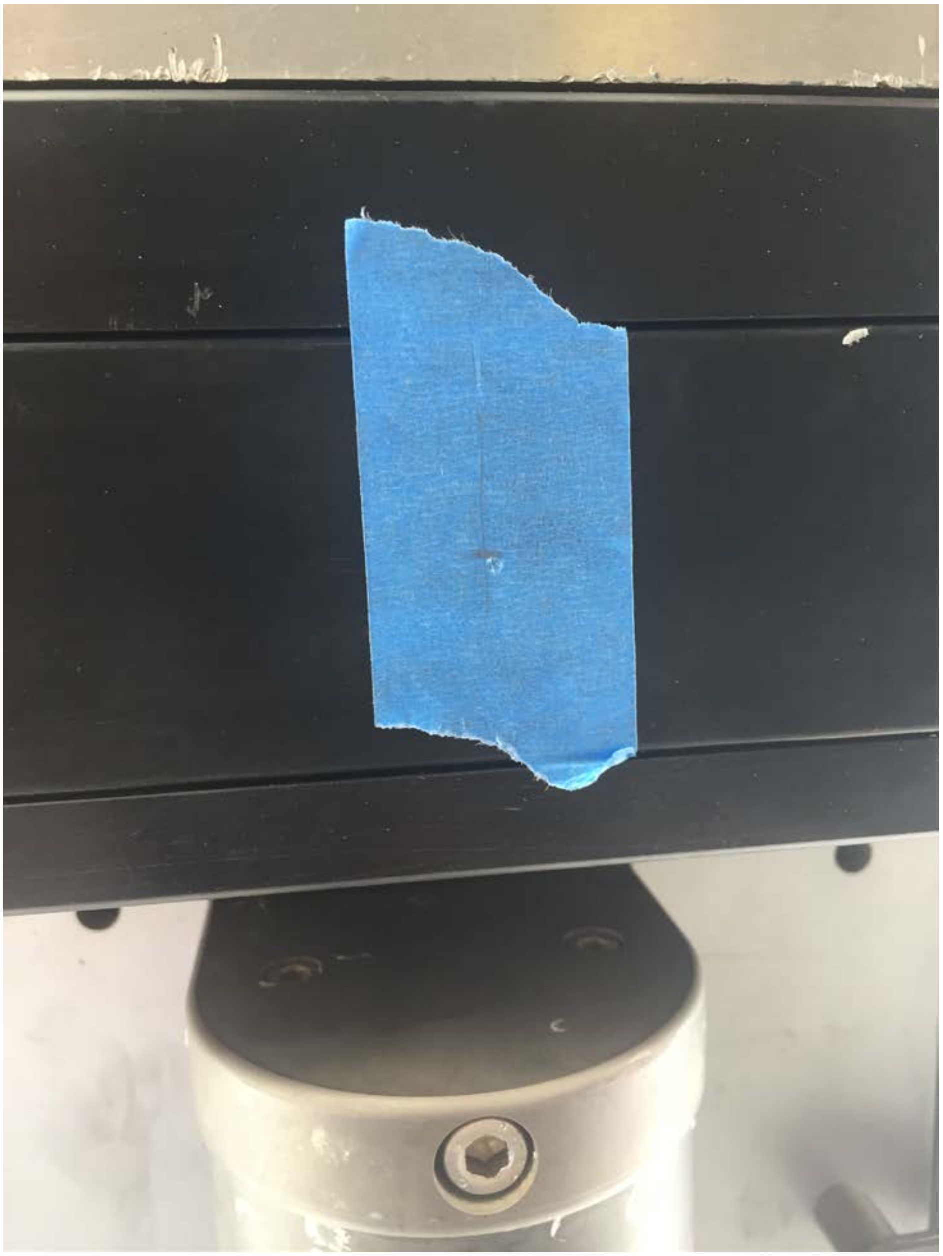
BM STAR 1

GPS PORT ARP

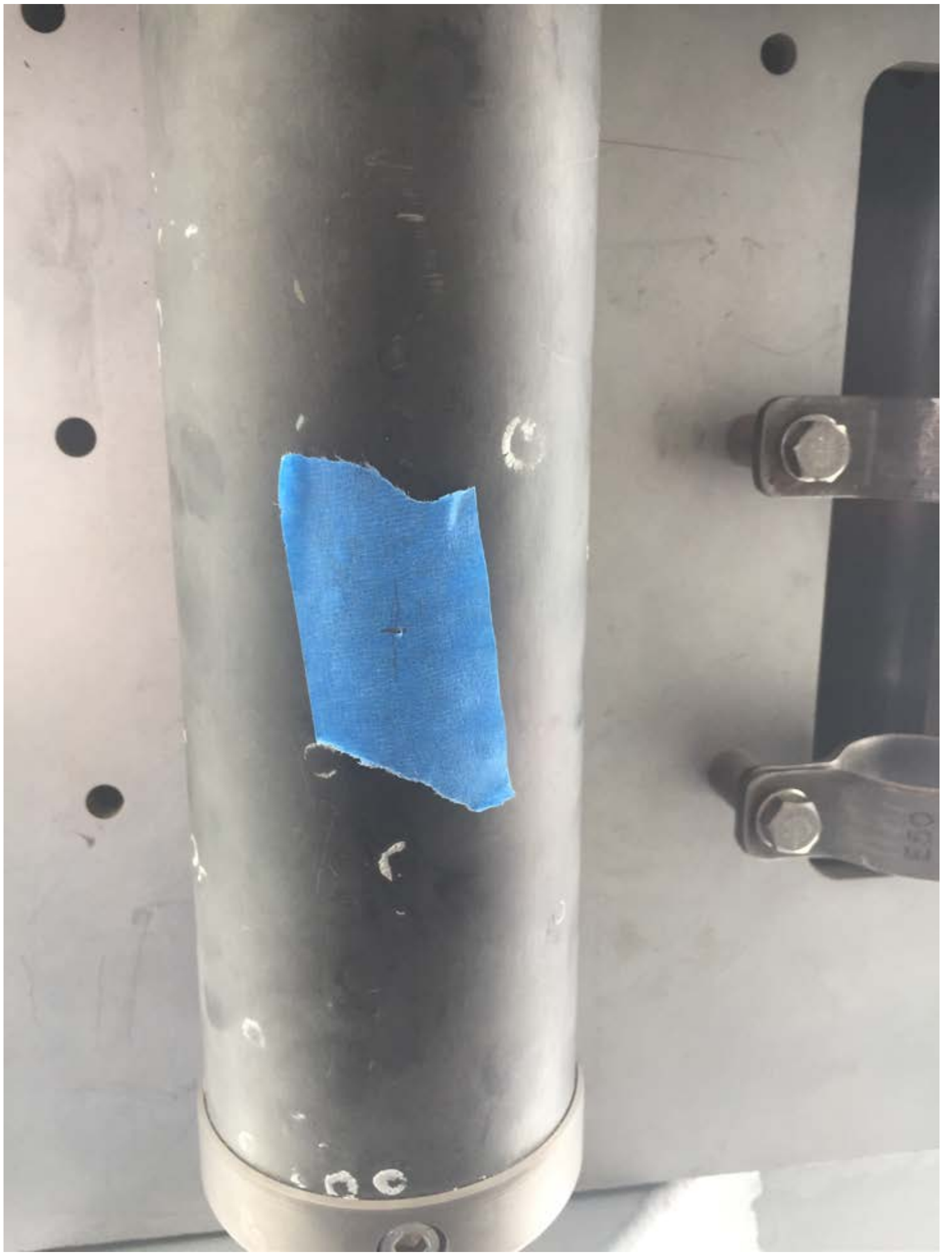
GPS STAR ARP

SIDE SCAN TOW POINT RM

RECEIVER



TRANSMITTER



KEEL BM FWD

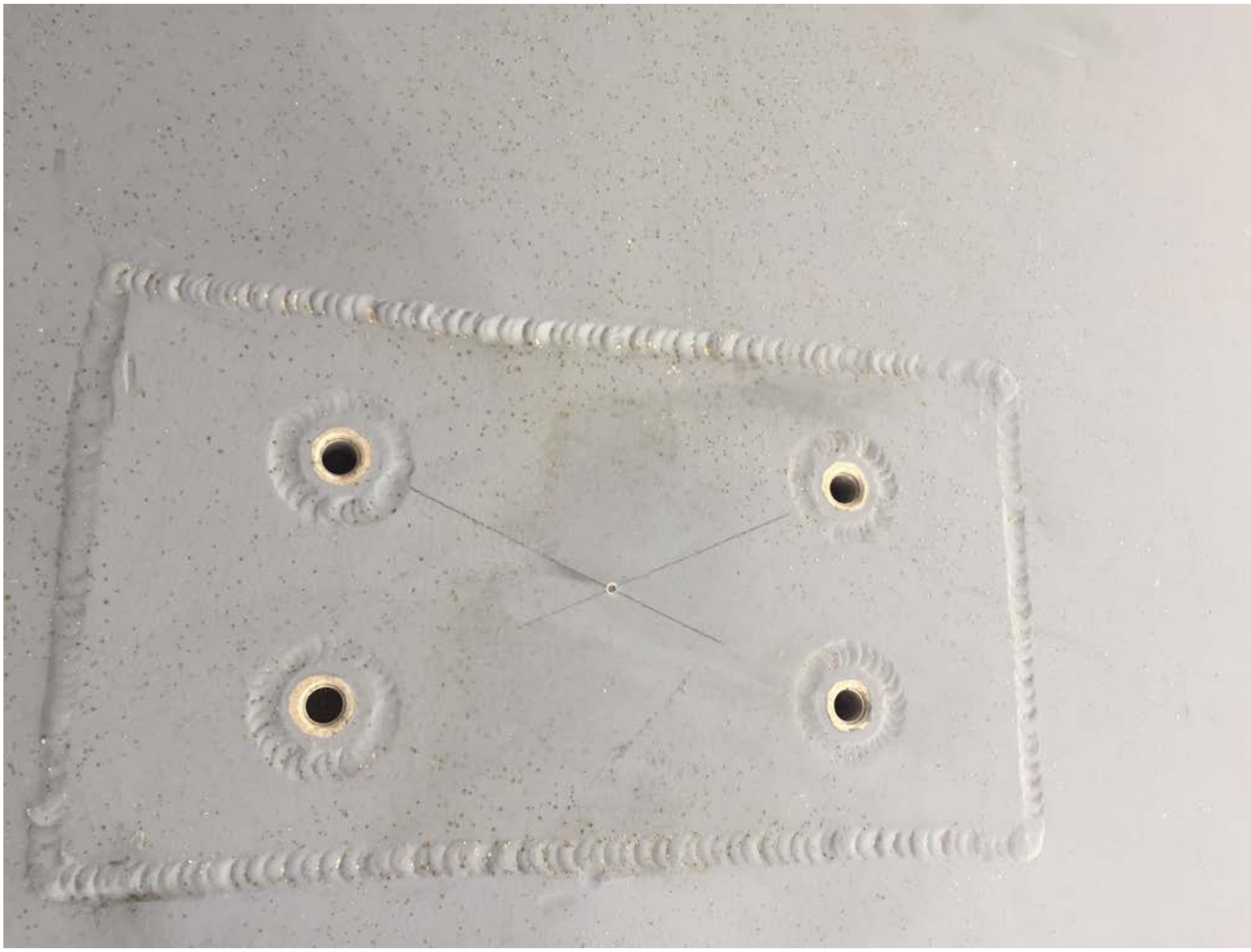
KEEL BM AFT

PORT SIDE SCAN HARD POINT FWD

PORT SIDE SCAN HARD POINT AFT

STAR SIDE SCAN HARD POINT FWD

STAR SIDE SCAN HARD POINT AFT



POST PROCESSING

The collected points were surveyed in an assumed coordinate system and needed to be translated to the point “IMU” as X=0, Y=0, Z=0. The azimuth from CL 4 to CL 1 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.

Transmitter center

The transmitter center was determined by measuring the length and width of the face (fwd to aft, port to starboard) and splitting the difference of the measurement. A temporary mark was placed on a piece of masking tape and measured.

Side Scan Tow Point Reference Mark

A reference mark for the Side Scan Sonar was established as part of this survey. The point of measurement can be described as a "." punch mark on the left-most middle bracket and is aft-facing on the side-scan arm.

Final Coordinate List

An excel spreadsheet labeled TJ_2904.xlsx is included with the project submission. Below is a report of the final coordinate listing.

2904 Boat Survey 2017

NAME	X (METERS)	Y (METERS)	Z (METERS)
IMU	0.000	0.000	0.000
CL1	3.583	-0.011	-1.358
CL3	-0.212	-0.004	-0.649
CL2	-0.171	-0.011	-2.653
CL4	-4.014	-0.012	-0.686
BM PORT 3	-1.598	-0.678	-2.648
BM PORT 2	-0.738	-0.549	-3.040
BM PORT 1	0.185	-1.453	-1.052
BM STAR 3	-1.607	0.649	-2.649
BM STAR 2	-0.743	0.533	-3.041
BM STAR 1	0.146	1.434	-1.060
GPS PORT ARP	-0.725	-0.762	-3.562
GPS STAR ARP	-0.730	0.726	-3.567
SIDE SCAN TOW POINT RM	-5.477	-0.061	-3.035
RECEIVER	0.269	-0.007	0.529
TRANSMITTER	0.050	0.000	0.535
KEEL BM FWD	0.467	0.003	0.631
KEEL BM AFT	-0.570	0.003	0.735
PORT SIDE SCAN HARD POINT FWD	1.130	-0.563	0.301
PORT SIDE SCAN HARD POINT AFT	0.209	-0.563	0.314
STAR SIDE SCAN HARD POINT FWD	1.123	0.579	0.300
STAR SIDE SCAN HARD POINT AFT	0.195	0.568	0.312

***NOTE Z VALUES ARE POSITIVE DOWNWARD**

SURVEY CLOSURE
The majority of points were established by occupying a temporary mark (TP 1) established on solid ground about 20 meters behind the stern of the boat. Throughout the survey, Horizontal and Vertical checks were made to the 2nd temporary point that was established on the lot (TP 2). At the end of the observations, a check point was collected and an inverse was computed.

TP 2
Δ X = 0.000 m
Δ Y = 0.001 m
Δ Z = 0.003 m

A second setup was required to collect two additional points. The instrument was setup on TP 2 and backsight TP 1. The initial survey setup checked TP 1 by:

CK TP 1
Δ X = 0.001 m
Δ Y = 0.000 m
Δ Z = 0.003 m

Following the collection of the additional points, a final check to TP 1 was performed and closure was:

CK TP 1
Δ X = 0.001 m
Δ Y = 0.001 m
Δ Z = 0.001 m

POS/MV Calibration Report

Field Unit: Thomas Jefferson

SYSTEM INFORMATION

Vessel: 2904

Date: 9/11/2017 **Dn:** 254

Personnel: Glomb, Brozstek, Hiteshew

PCS Serial # 3954

IP Address: 129.100.1.231

POS controller Version (Use Menu Help > About) 8.32

POS Version (Use Menu View > Statistics) MV-320 version 4

GPS Receivers

Primary Receiver N5036K17685, v.00421 channels 76 OMNSN 14

Secondary Receiver N5037K17791, v.00421 channels 76 OMNSN 14

CALIBRATION AREA

Location: Lambert Bend to Pinner Point

Approximate Position:

	D	M	S
Lat	36	51	54.37
Lon	76	19	15.1

DGPS Beacon Station: Marinestar float

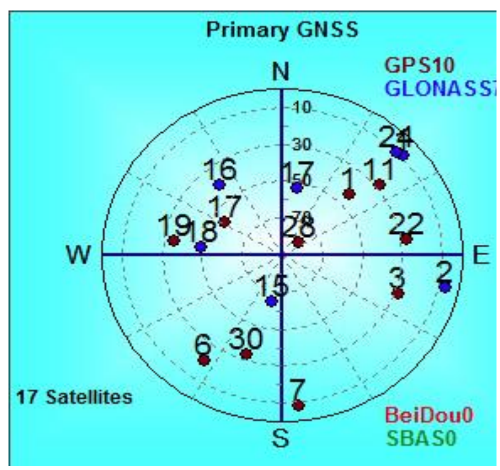
Frequency:

Satellite Constellation

(Use View> GPS Data)

Primary GPS (Port Antenna)

N



HDOP: 0.798

VDOP: 1.141

Sattelites in Use: 10

PDOP 2.232 (Use View> GAMS Solution)

Note:

POS/MV CONFIGURATION

Settings

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

User Entries, Pre-Calibration

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

Baseline Vector

0.061	X Component
1.456	YComponent
0.002	Z Component

Configuration Notes:

POS/MV CALIBRATION

Calibration Procedure:

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

Start time: 1359

End time: 1401

Heading accuracy achieved for calibration: 0.028

Calibration Results:

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

POS/MV Post-Calibration Values

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

Baseline Vector

0.003	X Component
1.49	YComponent
0.005	Z Component

GAMS Status Online? x

Save Settings? x

Calibration Notes: heading at 0.067 when starting GAMS

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

File Name: Posconfig_2904_Marinestar_09112017

GENERAL GUIDANCE

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:

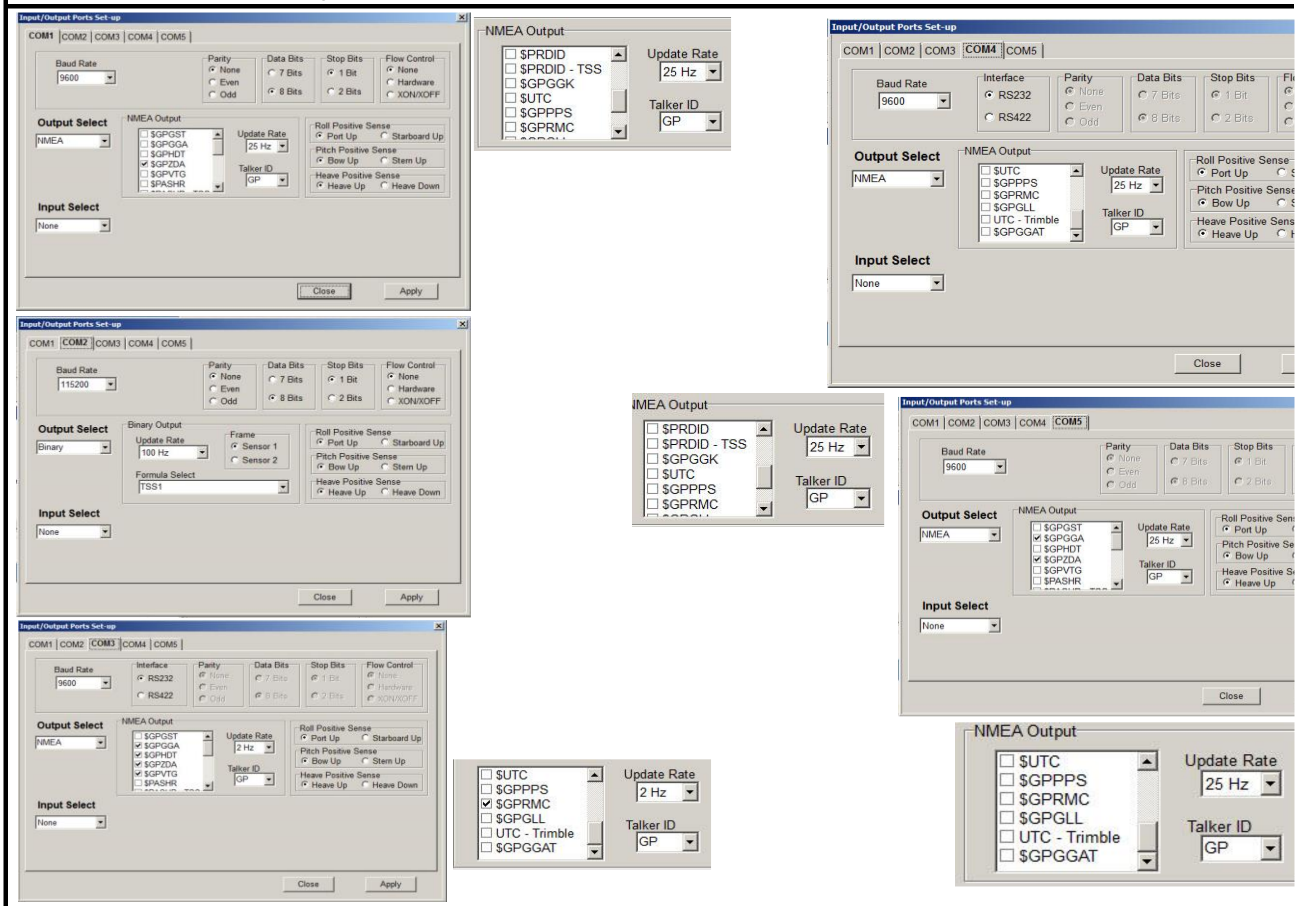
a) Heading rotation - apply a right-hand screw rotation θz about the z-axis to align one frame with the other.

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.

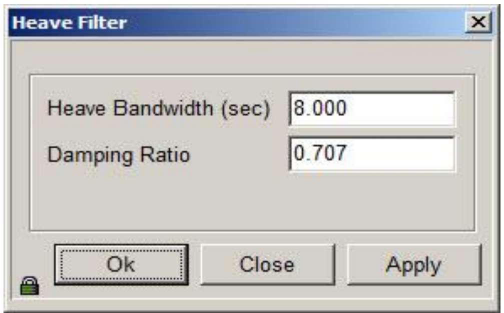
SETTINGS (insert screen grabs)

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

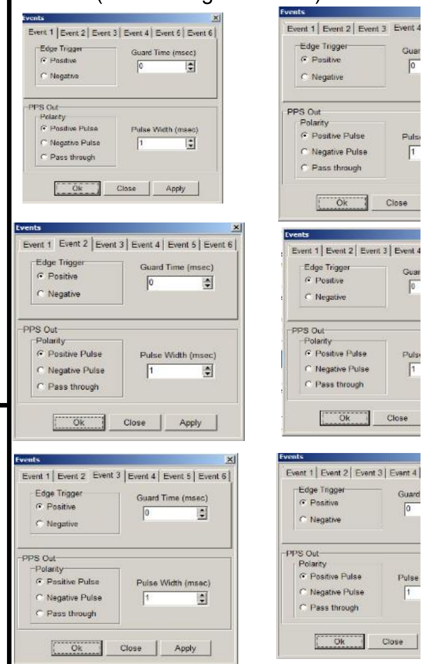


NOTE:

Heave Filter (Use Settings > Heave)



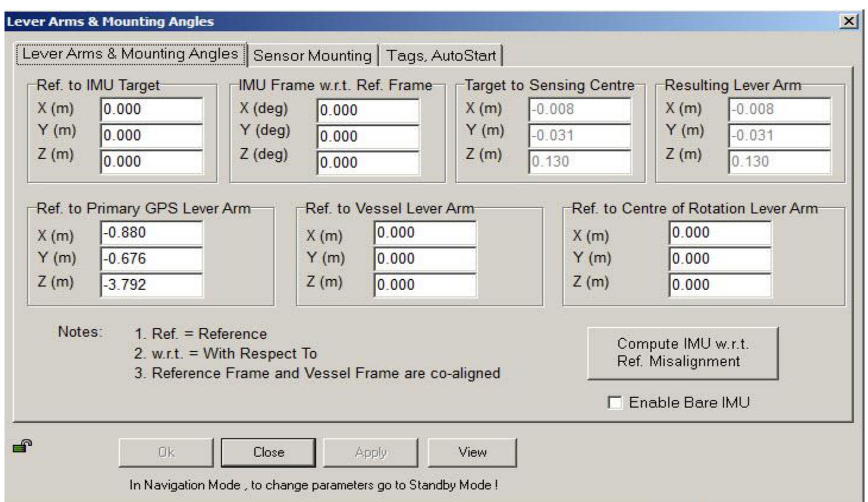
Events (Use Settings > Events)



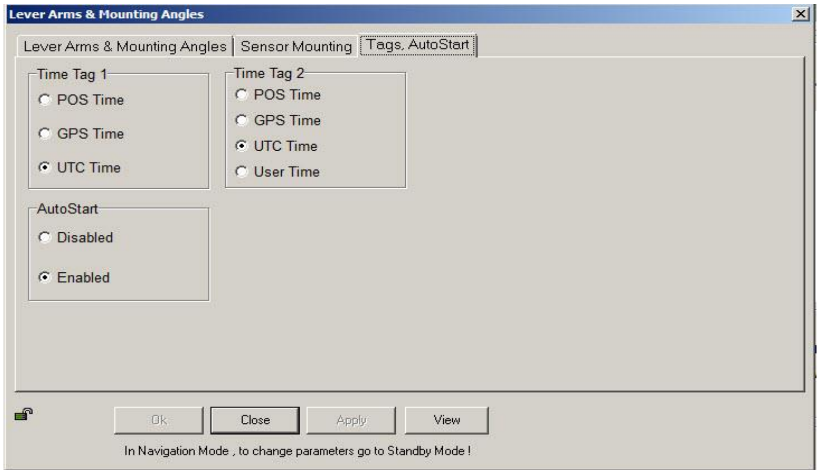
Time Sync (Use Settings > Time Sync)

NOT ON THE VERSION 4

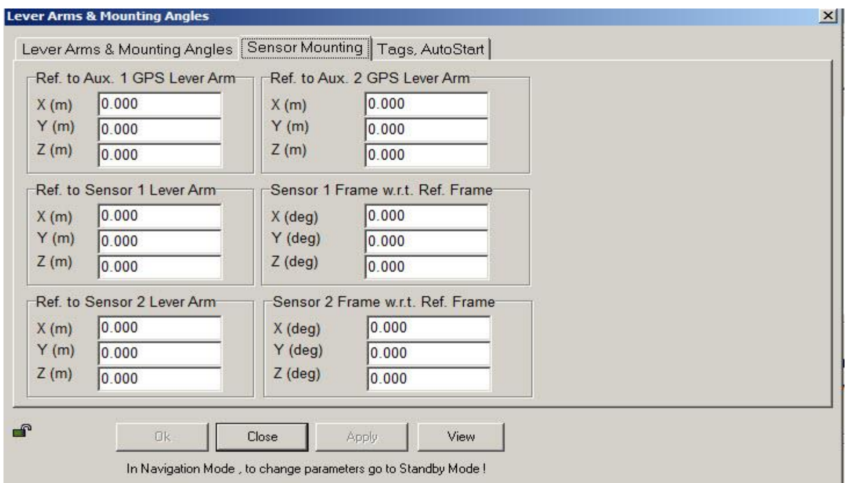
Installation (Use Settings > Installation)



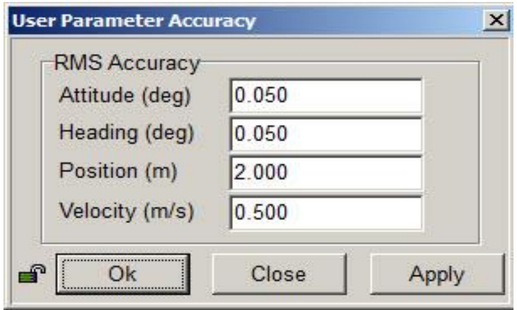
Tags, Multipath and Auto Start (Use Settings > Installation > Tags, Multipath and Auto Start)



Sensor Mounting (Use Settings > Installation > Sensor Mounting)



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

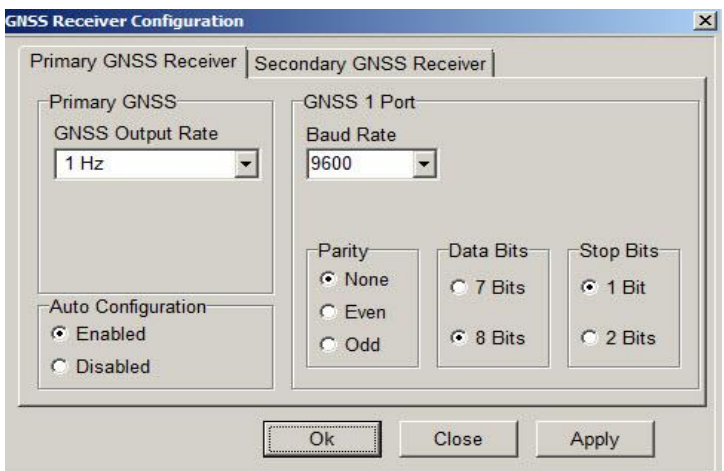


Frame Control (Use Tools > Config)

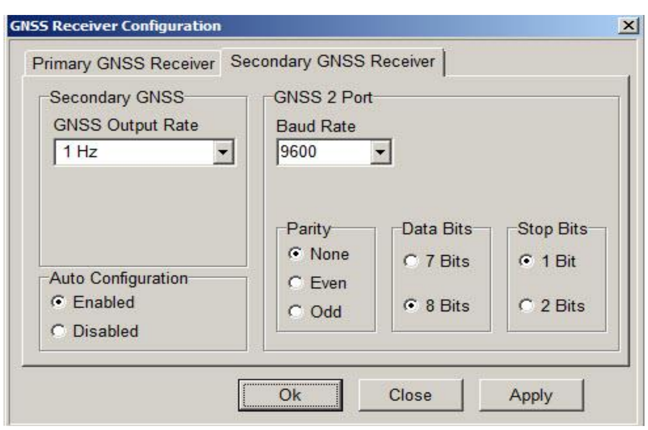
NOT ON THE VERSION 4

GPS Receiver Configuration (Use Settings> Installation> GPS Receiver Configuration)

Primary GPS Receiver



Secondary GPS Receiver



7

(m) (m) (m)
(m) (m) (m)


ow Control
None
Hardware
XON/XOFF
Starboard Up
Stern Up
Heave Down
Apply


Flow Control
None
Hardware
XON/XOFF
Starboard Up
Stern Up
Heave Down
Apply


Event 5
Event 6
Time (msec)
Width (msec)
Apply

Event 5
Event 6
Time (msec)
Width (msec)
Apply

Event 5
Event 6
Time (msec)
Width (msec)
Apply

POS/MV Calibration Report

Field Unit: Thomas Jefferson

SYSTEM INFORMATION

Vessel: S222

Date: 7/12/2017 **Dn:** 193

Personnel: Marcus,Hiteshew,Doroba

PCS Serial # 6497

IP Address: 129.100.1.231

POS controller Version (Use Menu Help > About) 8.6

POS Version (Use Menu View > Statistics) V5

GPS Receivers

Primary Receiver BD982 S/N 5409C86558

Secondary Receiver

CALIBRATION AREA

Location: E of Cape Henry

Approximate Position:

	D	M	S
Lat	36	54	13
Lon	75	50	35

DGPS Beacon Station: MarineStar

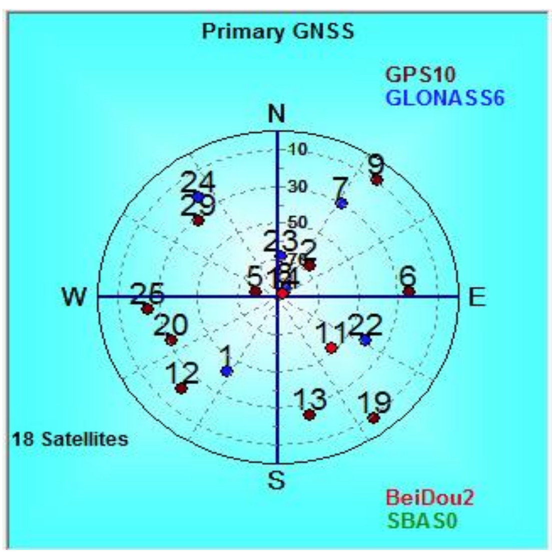
Frequency:

Satellite Constellation

(Use View> GPS Data)

Primary GPS (Port Antenna)

N



HDOP: 0.676

VDOP: 1.062

Sattelites in Use: 10

PDOP 2.000 (Use View> GAMS Solution)

Note:

POS/MV CONFIGURATION

Settings

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

User Entries, Pre-Calibration

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

Baseline Vector

0.019	X Component (m)
2.208	YComponent (m)
-0.009	Z Component (m)

Configuration Notes:

POS/MV CALIBRATION

Calibration Procedure:

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

Start time: 2341 UTC

End time: 0005

Heading accuracy achieved for calibration: 0.486

Calibration Results:

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

POS/MV Post-Calibration Values

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

Baseline Vector

0.019	X Component (m)
2.208	YComponent (m)
-0.009	Z Component (m)

GAMS Status Online? Yes

Save Settings? Yes

Calibration Notes:

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

File Name: PosConfig_13Jul2017.nvm

GENERAL GUIDANCE

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:

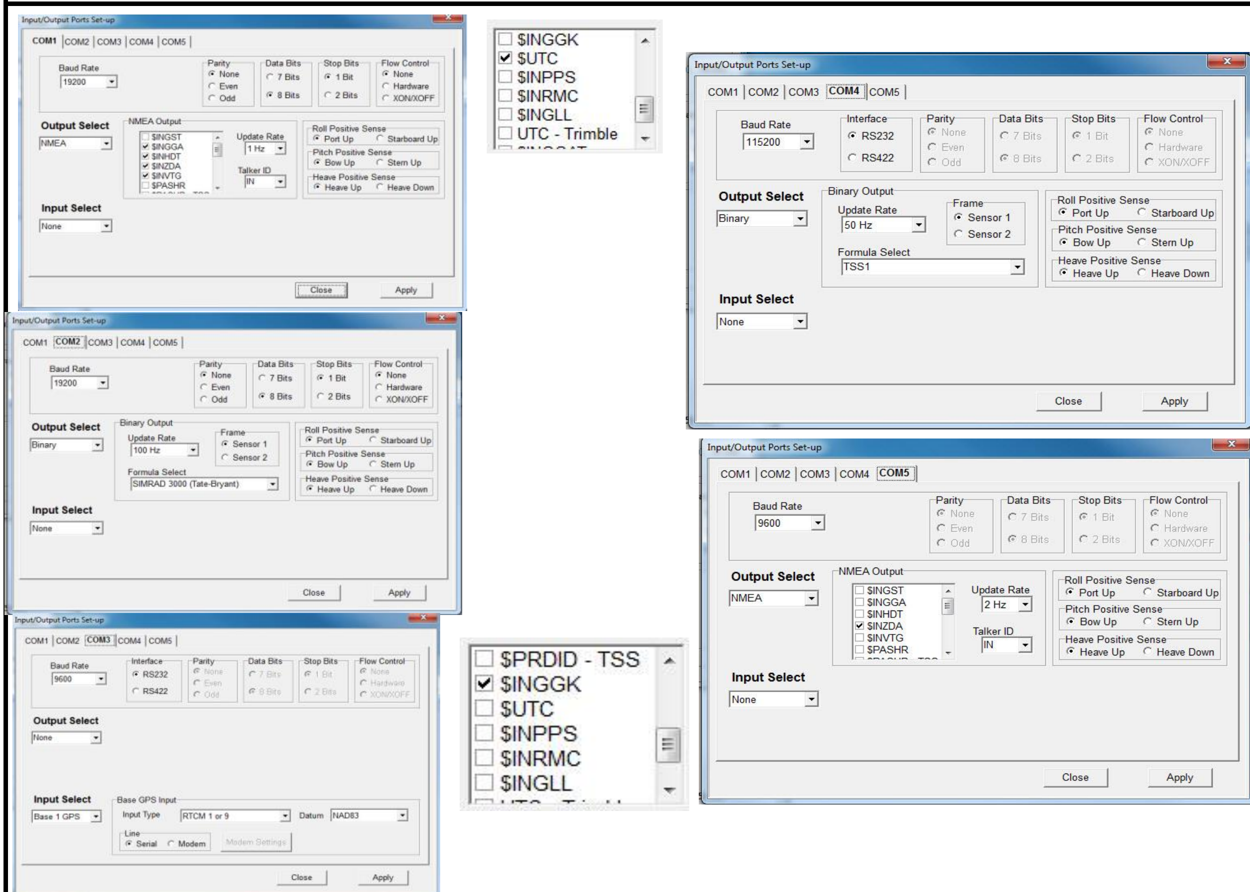
a) Heading rotation - apply a right-hand screw rotation θz about the z-axis to align one frame with the other.

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.

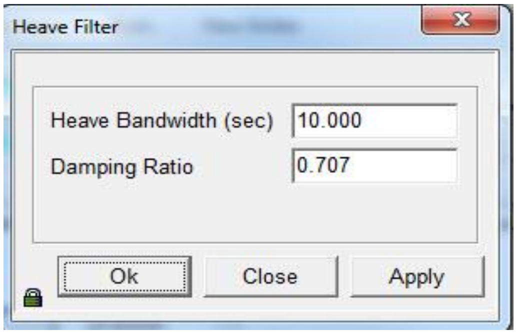
SETTINGS (insert screen grabs)

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

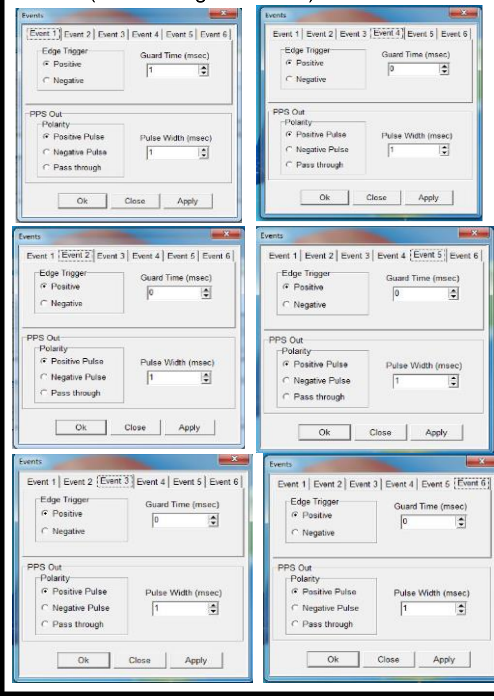


NOTE:

Heave Filter (Use Settings > Heave)



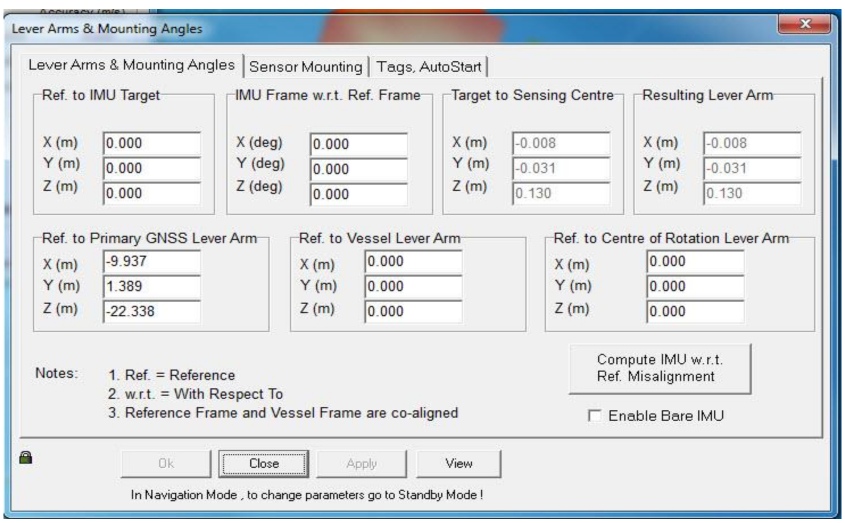
Events (Use Settings > Events)



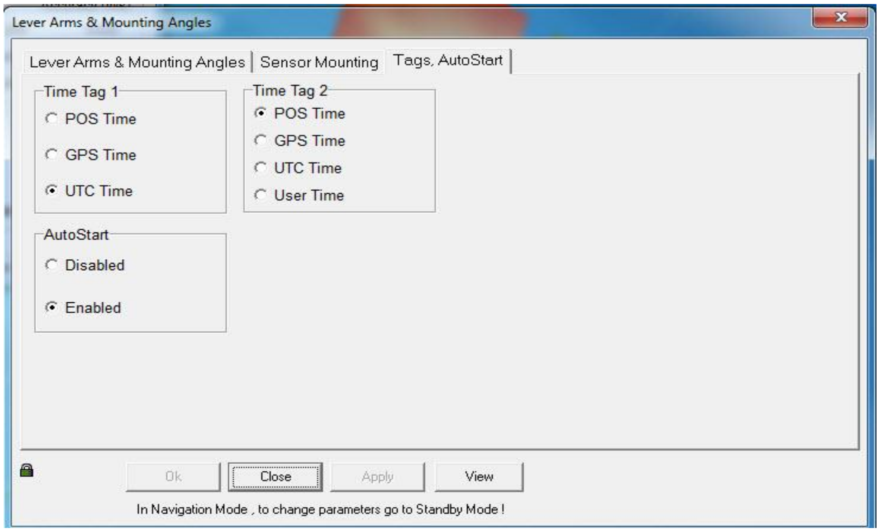
Time Sync (Use Settings > Time Sync)

NOT ON THE VERSION 4

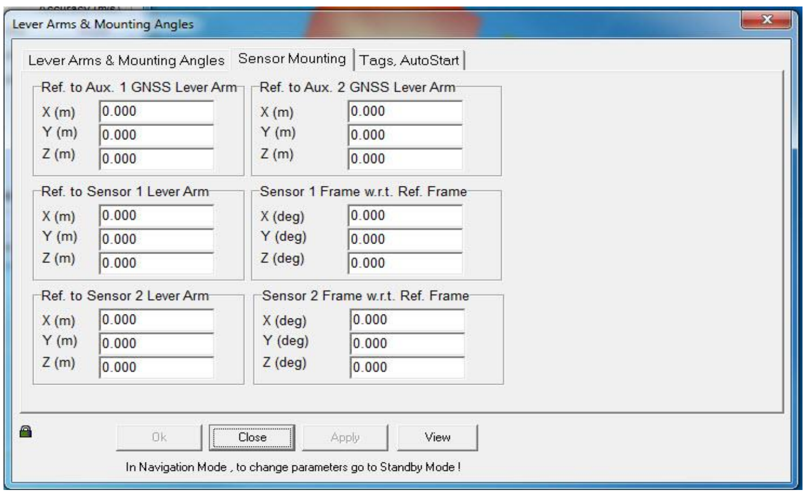
Installation (Use Settings > Installation)



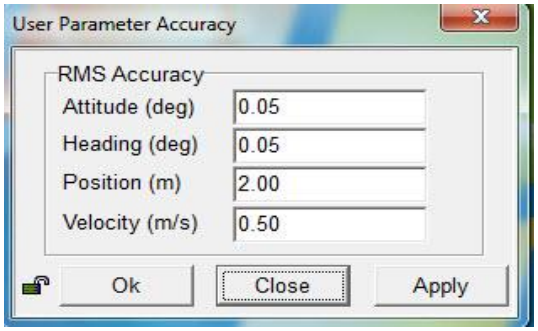
Tags, Multipath and Auto Start (Use Settings > Installation > Tags, Multipath and Auto Start)



Sensor Mounting (Use Settings > Installation > Sensor Mounting)



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

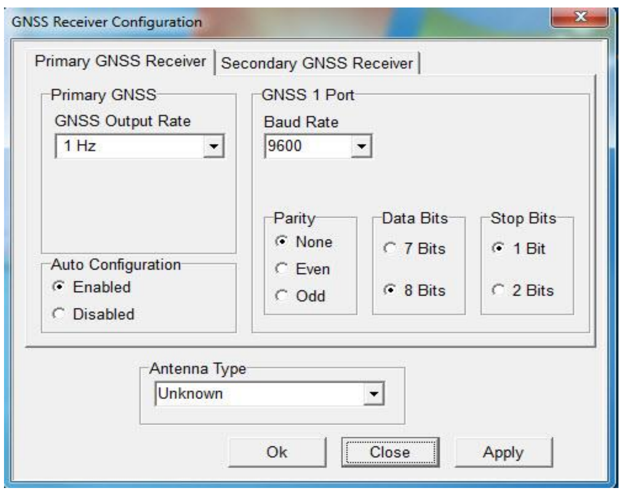


Frame Control (Use Tools > Config)

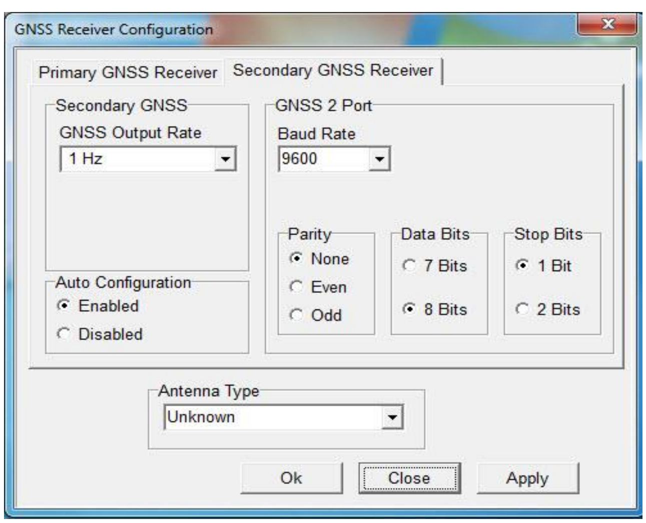
NOT ON THE VERSION 4

GPS Receiver Configuration (Use Settings> Installation> GPS Receiver Configuration)

Primary GPS Receiver



Secondary GPS Receiver



THOMAS JEFFERSON

Multibeam Echosounder Calibration   Vessel: S-222

Date Acquired: 8/19/2017 (DN231)

Processing Log

8/20/2017	231	Doroba, Stone, McMillan
Date	Dn	Personnel

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

☑ **TrueHeave applied**

☑ **SVP applied**

☑ **Tide applied** GPS Tide

Zone file

Lines merged ☑

Data cleaned to remove gross fliers ☑

Compute correctors in this order

1. Precise Timing **2. Pitch bias** **3. Roll bias** **4. Heading bias**

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

PATCH TEST RESULTS/CORRECTORS

Evaluators	Latency Lines Used	Latency (sec)	Pitch Lines Used	Pitch (deg)	Roll Lines Used	Roll (deg)	Yaw Lines Used
Doroba		0.0000		0.9233		0.1867	
Stone		0.0000		0.8800			
McMillan		0.0367				0.2067	
Bobby		0.0000		1.1633		0.2167	
Rosenberg		0.0400		0.9467		0.1933	

	Latency (sec)	Pitch (deg)	Roll (deg)
Averages	0.02	0.98	0.20
Standard Deviation	0.02	0.13	0.01
FINAL VALUES	0.02	0.98	0.20

Final Values based on

Resulting HVF File Name 2903_Reson7125_SV2_200kHz_2017.hvf

MRU Align StdDev gyro 0.43 Value from standard deviation of Heading offset values

MRU Align StdDev Roll/Pitch 0.07 Value from averaged standard deviations of pitch and rol

NARRATIVE

We need to figure out which beams to filter on STBD side and interference w SSS.

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

Name: 2903_7125_200kHz_2017 **Date:**

Yaw (deg)
-1.8533
-1.9900
-1.4767
-1.5067
-2.5367

-1.87

0.43

-1.87

l offset values

8/20/2017

THOMAS JEFFERSON

Multibeam Echosounder Calibration   Vessel: S-222

Date Acquired: 8/19/2017 (DN231)

Processing Log

8/20/2017	231	Doroba, Stone, McMillan
Date	Dn	Personnel

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

☑ **TrueHeave applied**

☑ **SVP applied**

☑ **Tide applied** GPS Tide

Zone file

Lines merged ☑

Data cleaned to remove gross fliers ☑

Compute correctors in this order

1. Precise Timing **2. Pitch bias** **3. Roll bias** **4. Heading bias**

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

PATCH TEST RESULTS/CORRECTORS

Evaluators	Latency Lines Used	**Latency (sec)**	Pitch Lines Used	**Pitch (deg)**	Roll Lines Used	**Roll (deg)**	Yaw Lines Used
Doroba		0.0000		0.6533		0.3000	
Stone		0.0000		0.4067		0.3267	
McMillan		0.0533		0.4733		0.3367	
Bobby		0.0067		0.6733		0.3233	
Rosenberg		0.0000				0.3133	

	Latency	Pitch	Roll
Averages	0.01	0.55	0.32
Standard Deviation	0.02	0.13	0.01
FINAL VALUES	0.01	0.55	0.32

Final Values based on

Resulting HVF File Name 2903_Reson7125_SV2_400kHz_2017.hvf

MRU Align StdDev gyro 0.32 Value from standard deviation of Heading offset values

MRU Align StdDev Roll/Pitch 0.07 Value from averaged standard deviations of pitch and rol

NARRATIVE

We need to figure out which beams to filter on STBD side and interference w SSS.

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

Name: 2903_7125_400kHz_2017 **Date:**

Yaw (deg)
-1.1000
-1.3733
-1.0200
-1.7367

-1.31
0.32
-1.31

l offset values

8/20/2017

THOMAS JEFFERSON

Multibeam Echosounder Calibration   Vessel: S-222

Date Acquired: 8/19/2017 (DN231)

Processing Log

8/13/2017	254	Bowker, Wood, Glomb, Hiteshew
Date	Dn	Personnel

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

☑ **TrueHeave applied**

☑ **SVP applied**

☑ **Tide applied** VDATUM K:\Yearly Reports\2017\HSRR\VDATUM_SEP\VDatumSEP\PATCHTEST_I

Zone file

Lines merged ☑

Data cleaned to remove gross fliers ☑

Compute correctors in this order

1. Precise Timing **2. Pitch bias** **3. Roll bias** **4. Heading bias**

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

PATCH TEST RESULTS/CORRECTORS

Evaluators	Latency Lines Used	Latency (sec)	Pitch Lines Used	Pitch (deg)	Roll Lines Used	Roll (deg)	Yaw Lines Used
Glomb		0.0000		2.3400		-0.0200	
Bowker		0.0000		2.3900		-0.0200	
Wood		0.0000		2.4500		-0.0200	
Hiteshew		#REF!		#REF!		#REF!	

	Latency (sec)	Pitch (deg)	Roll (deg)
Averages	#REF!	2.39	-0.02
Standard Deviation	#REF!	0.06	0.00
FINAL VALUES	#REF!	2.39	-0.02

Final Values based on

Resulting HVF File Name

MRU Align StdDev gyro 0.08 Value from standard deviation of Heading offset values

MRU Align StdDev Roll/Pitch 0.03 Value from averaged standard deviations of pitch and rol

NARRATIVE

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

Name: 2904_Reson7125_SV2_400kHz_2017_KAG.hvf **Date:**

_OCATION)XY

Yaw (deg)
-0.4700
-0.5000
-0.3500
#REF!

-0.44

0.08

-0.44

l offset values

9/13/2017

NOAA Launch 2904 Sidescan Calibration - 75mRS
Side Scan run on Dn231. MBES run on Dn254.

MBES Position of Contact

	Lat	Long
	36.8651381	-76.32110282

SSS Contacts	Lat	Long	Line Hdg	Lat Diff (m)	Long Diff (m)	Dist. (m)	Along Trk (m)	Across Trk (m)	Dist. (m)
1	36.8651361	-76.3211092	000	-0.22	-0.57	0.61	-0.57	-0.225	0.61
2	36.86515519	-76.3211189	090	1.90	-1.43	2.38	-1.90	-1.428	2.38
3	36.86515432	-76.3210875	180	1.80	1.36	2.26	-1.36	-1.802	2.26
4	36.86515003	-76.3211197	180	1.33	-1.50	2.00	1.50	-1.326	2.00
5	36.86514501	-76.3210844	180	0.77	1.64	1.81	-1.64	-0.767	1.81
6	36.86514279	-76.3210914	270	0.52	1.01	1.14	0.52	-1.011	1.14
7	36.86513692	-76.3211014	270	-0.13	0.12	0.18	-0.13	-0.124	0.18
8	36.86511936	-76.3211135	090	-2.08	-0.95	2.29	2.08	-0.952	2.29
9	36.86512713	-76.3211069	000	-1.22	-0.36	1.27	-0.36	-1.219	1.27
10	36.86512224	-76.3211084	090	-1.76	-0.50	1.83	1.76	-0.499	1.83
11	36.86512499	-76.3211205	90	-1.46	-1.57	2.14	-1.57	-1.457	2.14
N	10		Average:	-0.05	-0.25	1.63	-0.01		
DOF: 2N-1	19		StDev:	1.43	1.15	0.73	1.26		

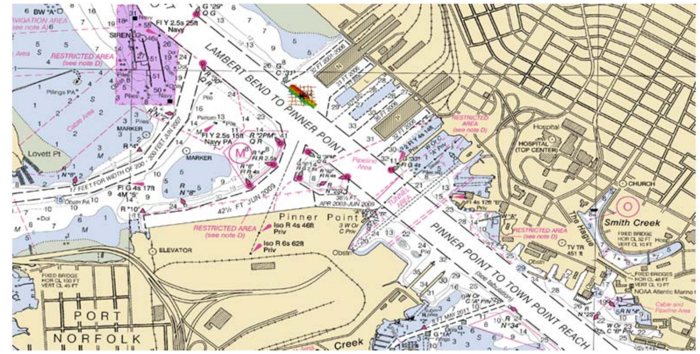


Figure 1. 1m[3] cube mobile target used to certify hull-mounted SSS on TJ HSL 2904.

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:

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

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)	5
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:

	best est.	95% Confidence	
x,y StDev	1.3	1.7	

And the 95% confidence inteval of the positioning error is:

Error	2.5	**3.4**	**PASS**

Note: FPM method of 1.96*RMS standard deviation

Error:	3.6	**PASS**

Alternate FPM method of mean radial distance plus 1.96*radial standard deviation

Error	3.1	**FAIL**

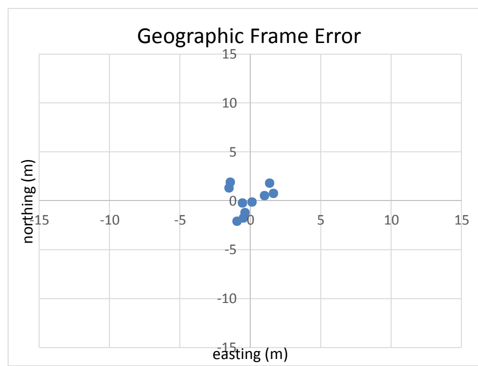


Figure 2: Contact position errors in a geographic refernece frame. Most contacts were reported southwest of the actual position.

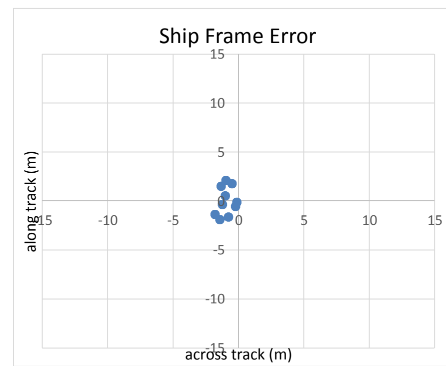


Figure 3: Contact position errors in a ship aligned reference frame.

NOAA Launch 2904 Sidescan Calibration - 75mRS
Side Scan run on Dn231. MBES run on Dn254.

MBES Position of Contact

	Lat	Long
	36.8651381	-76.32110282

SSS Contacts	Lat	Long	Line Hdg	Lat Diff (m)	Long Diff (m)	Dist. (m)	Along Trk (m)	Across Trk (m)	Dist. (m)
1	36.8651361	-76.3211092	000	-0.22	-0.57	0.61	-0.57	-0.225	0.61
2	36.86515519	-76.3211189	090	1.90	-1.43	2.38	-1.90	-1.428	2.38
3	36.86515432	-76.3210875	180	1.80	1.36	2.26	-1.36	-1.802	2.26
4	36.86515003	-76.3211197	180	1.33	-1.50	2.00	1.50	-1.326	2.00
5	36.86514501	-76.3210844	180	0.77	1.64	1.81	-1.64	-0.767	1.81
6	36.86514279	-76.3210914	270	0.52	1.01	1.14	0.52	-1.011	1.14
7	36.86513692	-76.3211014	270	-0.13	0.12	0.18	-0.13	-0.124	0.18
8	36.86511936	-76.3211135	090	-2.08	-0.95	2.29	2.08	-0.952	2.29
9	36.86512713	-76.3211069	000	-1.22	-0.36	1.27	-0.36	-1.219	1.27
10	36.86512224	-76.3211084	090	-1.76	-0.50	1.83	1.76	-0.499	1.83
11	36.86512499	-76.3211205	90	-1.46	-1.57	2.14	-1.57	-1.457	2.14
N	10		Average:	-0.05	-0.25	1.63	-0.01		
DOF: 2N-1	19		StDev:	1.43	1.15	0.73	1.26		

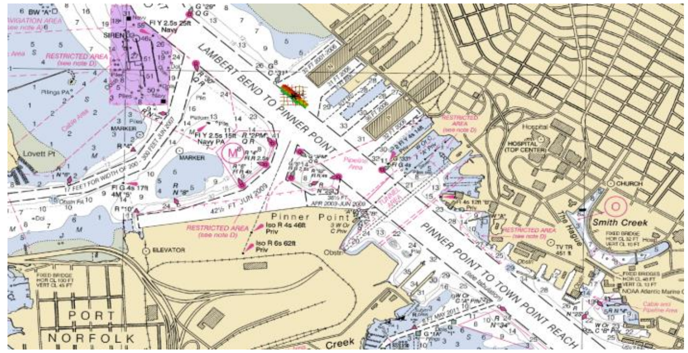


Figure 1. 1m^3 cube mobile target used to certify hull-mounted SSS on TJ HSL 2904.

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

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)	5
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:

	best est.	95% Confidence	
x,y StDev	1.3	1.7	

And the 95% confidence inteval of the positioning error is:

Error	2.5	**3.4**	**PASS**

Note: FPM method of 1.96*RMS standard deviation

Error:	3.6	**PASS**

Alternate FPM method of mean radial distance plus 1.96*radial standard deviation

Error	3.1	**FAIL**

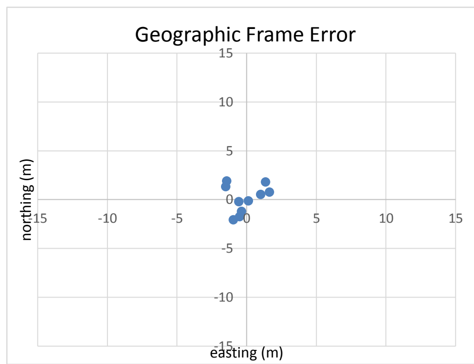


Figure 2: Contact position errors in a geographic refernece frame. Most contacts were reported southwest of the actual position.

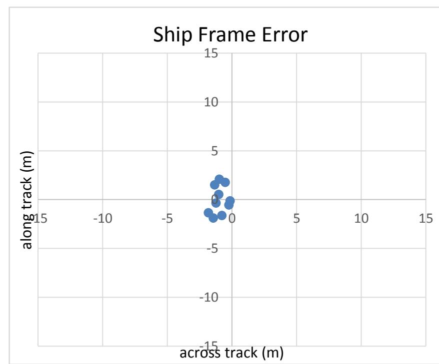


Figure 3: Contact position errors in a ship aligned reference frame.

THOMAS JEFFERSON

Multibeam Echosounder Calibration   Vessel: S-222

Date Acquired: 7/13/2017 (DN194)

Processing Log

Date	Dn	Personnel
7/13/2017	194	ACST Stone

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

☑ **TrueHeave applied** acs

☑ **SVP applied** acs

☑ **Tide applied** acs

Zone file

Lines merged ☑

Data cleaned to remove gross fliers ☐

Compute correctors in this order

1. Precise Timing **2. Pitch bias** **3. Roll bias** **4. Heading bias**

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

PATCH TEST RESULTS/CORRECTORS

Evaluators	Latency Lines Used	**Latency (sec)**	Pitch Lines Used	**Pitch (deg)**	Roll Lines Used	**Roll (deg)**	Yaw Lines Used
Stone		0.0000	12,13	0.1700	14, 15, 16, 17	-0.0400	14, 15, 16, 17
Hiteshew		0.0000	12,13	0.1900	14, 15, 16, 17	-0.0700	14, 15, 16, 17
Marcus		0.0000	12,13	0.1600	14, 15, 16, 17	0.0100	14, 15, 16, 17
Doroba		0.0000	12,13	0.1800	14,15,16,17	0.0500	14,15,16,17
Rice		0.0000	12,13	0.0000	14,15,16,17	0.0000	14,15,16,17

	Latency	Pitch	Roll
Averages	0.00	0.14	-0.01
Standard Deviation	0.00	0.08	0.05
FINAL VALUES	0.00	0.14	-0.01

Final Values based on

Resulting HVF File Name

MRU Align StdDev gyro 0.10 Value from standard deviation of Heading offset values

MRU Align StdDev Roll/Pitch 0.06 Value from averaged standard deviations of pitch and roll o

NARRATIVE

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

Name: ______________________________ **Date:**

Yaw (deg)
0.1000
0.0500
-0.1000

0.02
0.10
0.02

ffset values

THOMAS JEFFERSON

Multibeam Echosounder Calibration   Vessel: S-222

Date Acquired: 7/13/2017 (DN194)

Processing Log

Date	Dn	Personnel
7/13/2017	194	PS Marcus

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

☑ **TrueHeave applied** crm

☑ **SVP applied** crm

☑ **Tide applied** GPS Tide

Zone file

Lines merged ☑

Data cleaned to remove gross fliers ☐

Compute correctors in this order

1. Precise Timing   **2. Pitch bias**   **3. Roll bias**   **4. Heading bias**

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

PATCH TEST RESULTS/CORRECTORS

Evaluators	Latency Lines Used	**Latency (sec)**	Pitch Lines Used	**Pitch (deg)**	Roll Lines Used	**Roll (deg)**	Yaw Lines Used
Marcus		0.0000	13,14	0.0000	15,16,17,18		15,16,17,18
McMillan		0.0000	13,14	0.0000	15,16,17,18,	-0.0900	15,16,17,18
Hiteshew		0.0000	13,14	0.0500	15,16,17,18	-0.0700	15,16,17,18
Rice		0.0000	13,14	0.0000	15,16,17,18	0.0000	15,16,17,18
Doroba		0.0000	13,14		15,16,17,18	-0.0175	15,16,17,18
Forrest			13,14	0.0000			

	Latency (sec)	Pitch (deg)	Roll (deg)
Averages	0.00	0.01	-0.04
Standard Deviation	0.00	0.02	0.04
FINAL VALUES	0.00	0.01	-0.04

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 0.03 Value from averaged standard deviations of pitch and rol

NARRATIVE

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

Name: S222_EM2040_2017 **Date:**

Yaw (deg)
0.2000
0.3125
0.2000

0.24
0.06
0.24

l offset values

7/116/2017

NOAA Ship S222 2017 75m Range Scale Sidescan Calibration
Side Scan run on DN229. MBES not run.

2017 HSRR
S222 75m Range Scale
Side Scan Re-Certification
(TPU Upgrade) - August 2017

MBES Position of Contact

	Lat	Long
	32.00238561	-80.4578934

SSS Contacts	Lat	Long	Line Hdg	Lat Diff (m)	Long Diff (m)	Dist. (m)	Along Trk (m)	Across Trk (m)	Dist. (m)
1	32.0023870	-80.4579223	270	0.16	-2.73	2.73	0.16	2.726	2.73
2	32.00236939	-80.45791733	90	-1.80	-2.25	2.89	1.80	-2.255	2.89
3	32.00238333	-80.4579049	90	-0.25	-1.08	1.11	0.25	-1.083	1.11
4	32.00241408	-80.45788689	270	3.16	0.61	3.22	3.16	-0.614	3.22
5	32.00238033	-80.45786207	180	-0.59	2.95	3.01	-2.95	0.586	3.01
6	32.00239658	-80.45789544	90	1.22	-0.19	1.23	-1.22	-0.191	1.23
7	32.00233831	-80.45789233	180	-5.26	0.10	5.26	-0.10	5.256	5.26
8	32.00244697	-80.45788079	0	6.82	1.19	6.92	1.19	6.819	6.92
9	32.00237083	-80.45786709	0	-1.64	2.48	2.97	2.48	-1.642	2.97
10	32.00237472	-80.45790675	180	-1.21	-1.26	1.75	1.26	1.210	1.75

N	10	Average:	0.06	-0.02	3.11	0.02
DOF: 2N-1	19	StDev:	3.22	1.88	1.79	2.57

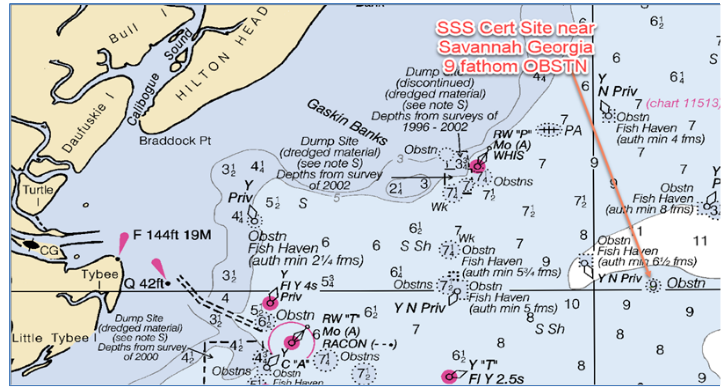


Figure 1: 2017 HSRR 75m Range Scale Side Scan Cert confidence check siteoff False Cape, NC.

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:

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

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:

	best est.	95% Confidence	
x,y StDev	2.6	3.5	
Error	5.0	**6.9**	**PASS**

And the 95% confidence inteval of the positioning error is given in the Error row above.

Note: FPM method of 1.96*RMS standard deviation

Error: 7.3 **PASS**

Alternate FPM method of mean radial distance plus 1.96*radial standard deviation

Error 6.6 **FAIL**

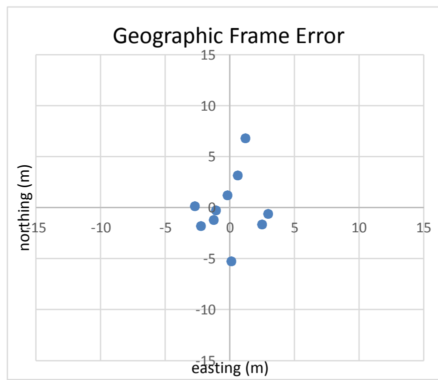


Figure 2: Contact position errors in a geographic refernece frame. Most contacts were reported east of the actual position.

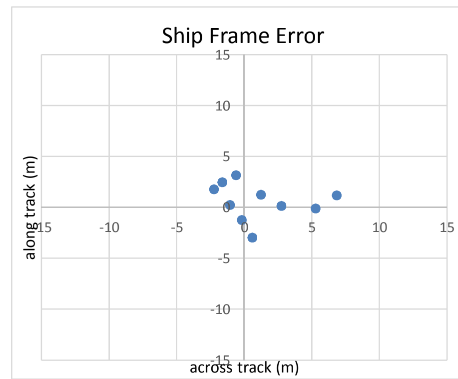


Figure 3: Contact position errors in a ship aligned refernece frame.

NOAA Launch 2903 Sidescan Calibration
Side Scan run on Dn231. MBES run on Dn231.
50m Range Scale

MBES Position of Contact

	Lat	Long
	32.00307	-80.604389

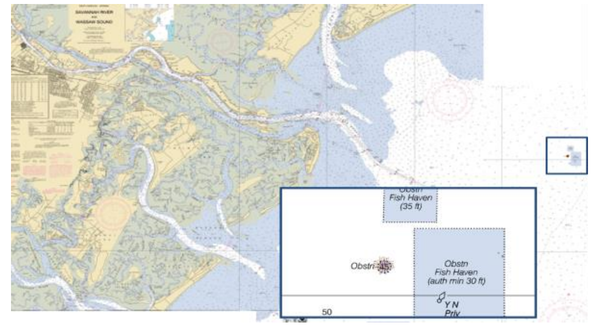


Figure 1: 45ft obstruction offshore of the Approaches to Savannah used to certify hull-mounted SSS on TJ HSL 2903.

SSS Contacts			Line Hdg	Lat Diff (m)	Long Diff (m)	Dist. (m)	Along Trk (m)	Across Trk (m)	Dist. (m)
	32.0030820	-80.6043720							
2	32.003086	-80.604369	181	1.78	1.88	2.59	-1.85	-1.811	2.59
3	32.003074	-80.604378	000	0.44	1.04	1.13	1.04	0.444	1.13
4	32.003076	-80.604385	180	0.67	0.38	0.77	-0.38	-0.667	0.77
5	32.003076	-80.604365	001	0.67	2.26	2.36	2.25	0.706	2.36
6	32.003063	-80.604386	181	-0.78	0.28	0.83	-0.30	0.773	0.83
7	32.003064	-80.604396	092	-0.67	-0.66	0.94	0.69	-0.636	0.94
8	32.003074	-80.604379	271	0.44	0.94	1.04	0.46	-0.934	1.04
9	32.003082	-80.60436	091	1.33	2.73	3.04	-1.38	2.709	3.04
10	32.003066	-80.604369	272	-0.44	1.88	1.94	-0.38	-1.899	1.94
12	32.003067	-80.604377	271	-0.33	1.13	1.18	-0.31	-1.136	1.18
N	10		Average:	0.31	1.19	1.58	0.75		
DOF: 2N-1	19		StDev:	0.86	1.03	0.83	1.02		

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

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

So:

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

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:

	best est.	95% Confidence	
x,y StDev	1.0	1.4	

And the 95% confidence inteval of the positioning error is:

Error	2.0	**2.8**	**PASS**

Note: FPM method of 1.96*RMS standard deviation

Error:	2.6	**PASS**

Alternate FPM method of mean radial distance plus 1.96*radial standard deviation

Error	3.2	**FAIL**

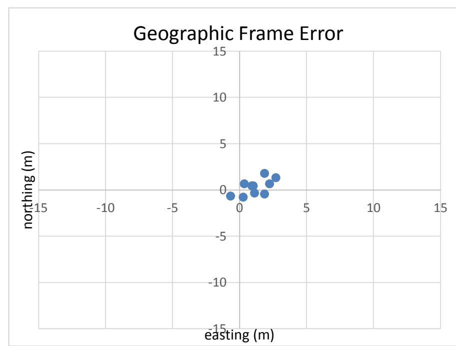


Figure 2: Contact position errors in a geographic refernece frame. Most contacts were reported east of the actual position.

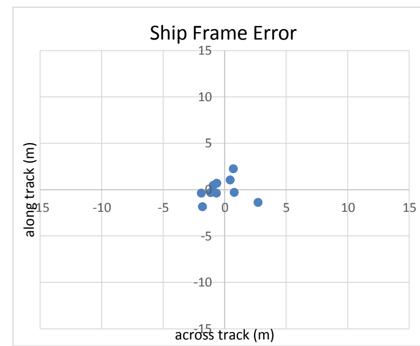


Figure 3: Contact position errors in a ship aligned refernece frame.

NOAA Launch 2903 Sidescan Calibration
Side Scan run on Dn231. MBES run on Dn231.

MBES Position of Contact

	Lat	Long
	32.00307	-80.604389

SSS Contacts

	Lat	Long	Line Hdg	Lat Diff (m)	Long Diff (m)	Dist. (m)	Along Trk (m)	Across Trk (m)	Dist. (m)
2	32.00305	-80.6043910	181	-2.22	-0.19	2.23	0.15	2.225	2.23
3	32.003065	-80.6044030	000	-0.56	-1.32	1.43	-1.32	-0.556	1.43
4	32.003081	-80.6043950	180	1.22	-0.57	1.35	0.57	-1.222	1.35
5	32.003053	-80.6043540	001	-1.89	3.30	3.80	3.33	-1.831	3.80
6	32.003085	-80.6043960	181	1.67	-0.66	1.79	0.69	-1.655	1.79
7	32.003084	-80.6043900	092	1.56	-0.09	1.56	-1.55	-0.148	1.56
9	32.003053	-80.6044150	091	-1.89	-2.45	3.09	1.93	-2.417	3.09
10	32.003052	-80.6044160	272	-2.00	-2.54	3.24	-2.09	2.473	3.24
	32.003072	-80.6044220		0.22	-3.11	3.12	-3.11	0.222	3.12
	32.003062	-80.6044210		-0.89	-3.02	3.14	-3.02	-0.889	3.14
N	8		Average:	-0.48	-1.06	2.48	-0.54		
DOF: 2N-1	15		StDev:	1.55	1.92	0.90	1.72		

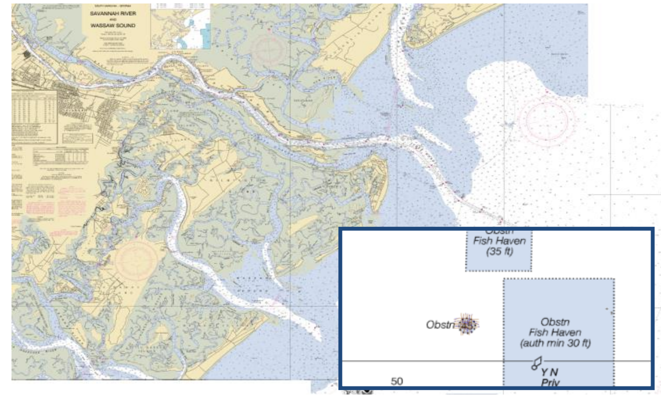


Figure 1. Charted 45ft obstuction used to certify hull-mounted

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:

	best est.	95% Confidence	
x,y StDev	1.7	2.5	

And the 95% confidence inteval of the positioning error is:

Error	3.4	**4.8**	**PASS**

Note: FPM method of 1.96*RMS standard deviation

Error: 4.8 **PASS**

Alternate FPM method of mean radial distance plus 1.96*radial standard deviation

Error 4.3 **FAIL**

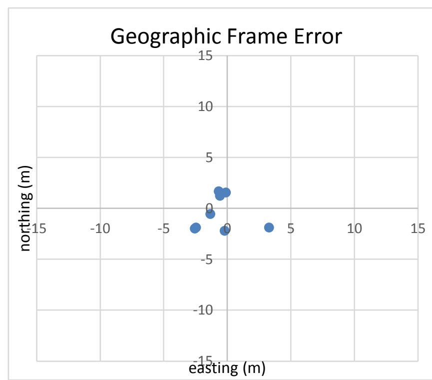


Figure 2: Contact position errors in a geographic refernece frame. Most contacts were reported southwest of the actual position.

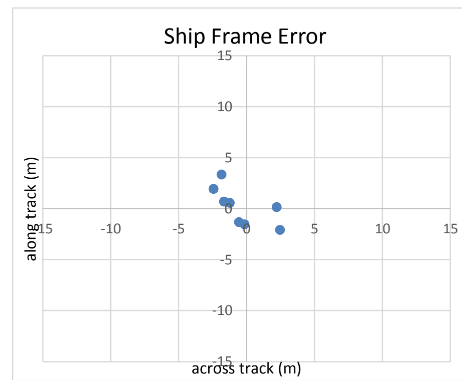


Figure 3: Contact position errors in a ship aligned reference frame.

NOAA SHIP THOMAS JEFFERSON EM710 AND EM2040 ACCEPTANCE TESTING

With Hydrographic Systems and Technology Programs Multibeam Sonar Acceptance Procedures

DATES
2016 October 14 to 20

Glen Rice
NOAA Office of Coast Survey

Executive Summary

A Kongsberg EM2040 multibeam and an EM710 MKII multibeam were installed aboard NOAA Ship *Thomas Jefferson* during an extended shipyard period at the Coast Guard yard in Curtis Bay in Baltimore, MD during the spring and summer of 2016. After a short stay at the Atlantic Marine Operations Center in Norfolk, VA, the ship proceeded with acceptance testing of the new survey systems in the areas between Norfolk and Hudson Canyon during the third week of October, 2016, with the assistance of Office of Coast Survey and Kongsberg personnel.

All portions of the Office of Coast Survey Sonar Acceptance Procedures were addressed, but the value of some tests were limited by the physical oceanography during testing. While working to confirm proper integration and operation of the new survey systems some important limitations to the installation were uncovered and characterized.

Key findings:

1. Both the EM2040 and EM710 are properly integrated with the supporting sensors.
2. A significant artifact presents itself in the outer beams of both multibeams. This artifact is transient and not motion correlated. While troubleshooting of this artifact is ongoing, at this time it is believed to be associated with the specific installation and not a defect in the hardware. Efforts to solve this problem include:
    a. Bringing the paint covering both transducers to Kongsberg specifications.
    b. Removing the fairlead forward of the transducer installation.

    It is not yet known if these efforts will resolve this artifact. In the interim it is recommended that the ship limit the survey swath to 45 degrees on either side by running in Single Sector mode, although the problem still persists at times even within the reduced swath.

3. A backscatter artifact persists on the port side as a small section of depressed backscatter and at 45 from vertical in the 200 kHz mode of the EM2040. Efforts to solve this problem include:
    a. Bringing the paint covering the EM2040 transducer to Kongsberg specifications.
    b. Removing filler material added during the previous shipyard to smooth the surface around the transducer.
    c. Lowering the EM2040 transmitter to meet current Kongsberg specifications.

    It is not yet known if these efforts will resolve this artifact.

4. A recommended Caris HIPS workflow had been provided to the ship. This recommended workflow is recognized as restricted to specific steps and integrating specific data to avoid post processing pitfalls.

While preliminary steps have been taken to remedy the problems described above, testing is still ongoing. Coast Survey plans to stay engaged in finding and implementing a solution to the described artifacts such that the survey systems can be used to their full potential.

Contents

1 General Overview

The NOAA Ship *Thomas Jefferson* was dry docked in the U.S. Coast Guard Curtis Bay Shipyard in Baltimore, MD, during 2016 to replace a defunct Kongsberg EM1002 with a new Kongsberg EM710 MKII 1° x 0.5° multibeam echo sounder, and replace a pair of Reson 7125s with an EM2040. Coast Survey Hydrographic Systems and Technology Branch (HSTB) personnel were on board for the acceptance cruise to assist OMAO Marine Engineering with integration and testing of the new systems. The cruise departed from Norfolk, VA on Friday, 14 October 2016, and returned to Norfolk on Thursday, 20 October, with the ship traveling as far as the deep end of Hudson Canyon.

Originally the USNS *Littlehales*, NOAA Ship *Thomas Jefferson* (Figure 1) is a 63 meter long hydrographic vessel built by Halter Marine in 1991. Propulsion includes one main engine plus a bow thruster. An additional smaller drive on the main shaft is only used for maneuvering. *Thomas Jefferson* conducts bathymetric surveys in the Caribbean and the East Coast of the United States, generally in support of Office of Coast Survey. Other echo sounders on the ship include a bridge fathometer, Doppler speed log, and several Simrad ES60s. A Knudsen sub-bottom profiler transducer is mounted but has not been commissioned, and is thus not currently usable.

Figure 1- NOAA Ship Thomas Jefferson in the Coast Guard yard.

The Kongsberg EM2040 multibeam echo sounder is the second EM2040 in the NOAA fleet, but the first with the new "slim PU" design. This version should be supported for longer with firmware updates extending the usable life. The Kongsberg EM710 MKII multibeam echo sounder is the second of its kind in the NOAA Fleet, with one installed the previous year aboard NOAA Ship *Nancy Foster*. Both the EM710 and EM2040 were mounted on a new pod (Figure 2) on centerline and near the location of the old EM1002. Testing of the new echo sounders followed the HSTB Sonar Acceptance Procedures, version 1.0. Visiting personnel to support acceptance work included Glen Rice from HSTB, Neil Weston from Coast Survey, with Paul Johnson and Dr. Anand Hiroji from the University of New Hampshire Center for Coastal and Ocean Mapping. Anthony Dalheim from Kongsberg Underwater Technologies Inc. (KUTI) was also aboard to support installation and acceptance work.

Figure 2- NOAA Ship Thomas Jefferson *survey transducers from below and looking aft. The Kongsberg EM710 MKII 1° x 0.5° system includes the top two transducers in center pod, while the EM2040 system includes the bottom two. Also visible are the ES60 transducers in the pod on the right (port). The left (starboard) pod has an intake for an inboard surface sound speed sensor.*

2 Overview of schedule and conditions

2.1 Preplanning

Planning for the acceptance cruise evolved with the personnel involved and timing of the cruise. HSTB personnel coordinated with the ship's command and Coast Survey to establish a plan for acceptance testing. Eight days were allocated by Office of Marine and Aviation Operations for acceptance testing, including transit time.

1. Bow Mariner
2. Tom's Canyon
3. Hudson Canyon
4. South of Hudson Canyon
5. Deep Test Sites
6. Deep Noise Site
7. Multi-frequency Backscatter

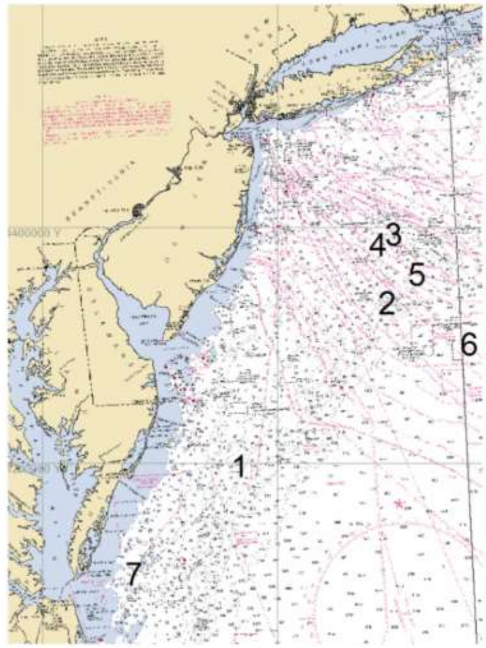


Figure 3 - Acceptance testing planned locations as displayed on chart 13003.

2.2 Executed Schedule

- Tuesday, 11 October – Rice Arrives aboard in Norfolk
- Wednesday, 12 October – Underway in Chesapeake Bay for crew familiarization. Some initial integration testing and interference testing with the EM2040.
- Thursday, 13 October – Initial attempt at a patch test but conditions are unsuitable. Shallow water noise testing, some tests with doppler speed log on.
- Friday, 14 October – Johnson, Hiroji, Weston and Dalheim arrive via small boat transfer to begin acceptance cruise.
- Saturday, 15 October –Second attempt at EM2040 Patch Test at Bow Mariner wreck site.
- Sunday, 16 October – Patch Test at Tom's Canyon for EM710 and EM2040, EM2040 Extinction Test at Hudson Canyon.
- Monday, 17 October – Extinction Test for EM710 and EM2040, EM710 Medium and Deep Accuracy Testing.
- Tuesday, 18 October – Extinction Test for EM710 and EM2040, deep noise test for EM2040 and EM710.
- Wednesday, 19 October – At Bow Mariner for EM2040 Accuracy, EM710 Shallow Accuracy, and EM710 and EM2040 Object Detection, EM710 and EM2040 Shallow Noise.
- Thursday, 20 October – Multispectral backscatter testing, arrive in port.

3 Pre-Installation Testing

3.1 Test Data Processing Workflow

NOAA Ship *Thomas Jefferson's* new survey system required a different configuration and slightly different workflow than was used for past NOAA Kongsberg systems. Other Kongsberg multibeams in the NOAA fleet have been configured with the reference point at the transmit transducer to overcome deficiencies in the treatment of lever arms in Caris HIPS for these systems ([1], [2]). *Thomas Jefferson* has two Kongsberg multibeam systems and they cannot both be identified as the primary reference point for the survey system. In June of 2016, HSTB conducted an analysis of the updated CARIS HIPS 9 ray tracing algorithm to confirm proper application of lever arms [3]. While this analysis showed the lever arm issue had been resolved, there are still post-processing impacts to the location of the reference point. This is discussed further in Section 7.1.

We also tested the application of the ellipsoid height from a raw Kongsberg *.all file using Caris 9.1 and Qimera 1.3. Thomas Jefferson has regularly used MarineStar with their POS M/V to provide real time ellipsoid heights that can be used directly, cutting down on post processing time. Heights are recorded within the Kongberg data both as the original NMEA string in the position record and as a separate height record. Testing demonstrated that when the GGA NMEA message was used the resulting depths were referenced to mean sea level (MSL). The GGA message format accommodates both the height relative to MSL as well as the separation to the ellipsoid used to derive MSL. However, the POS M/V does not populate the separation value in favor of higher precision elsewhere in the record, which means there is a lack of specification in the derivation of the datum. To avoid this ambiguity, *Thomas Jefferson* was configured to use the GGK message, which only contains ellipsoid heights. This was done with the intention that ellipsoid heights could be pulled directly into Caris through the *.all file without the need to merge additional positioning files, thus streamlining the path to survey on the ellipsoid. Testing in both Caris HIPS and Qimera 1.3.6 was successful in producing ellipsoid referenced results.

3.2 Determine data rates and file size

We estimated the anticipated data acquisition rate using the data collected during the extinction test (Section 6.5). The purpose of this analysis is to aid in the planning of appropriate storage volume for an anticipated survey. Data rates with and without water column files are described. Water column is recorded to a separate *.wcd file, but total water column rates should be considered the combined bathymetry and water column since both files are logged simultaneously. The bathymetry files contain a number of records, including backscatter, attitude, vessel offsets and settings, etc. No effort was made to quantify or predict the uncertainty associated with these estimates. The data rates strongly depend on depth. For example, the EM710 logs water-column data approximately 100 times faster in shallow water than in deep water. This means that continuous logging of full water column may be practical in deep water (e.g. for methane seep detection), but may be prohibitive in shallow water.

The EM2040 data collection rates without water column are shown in Figure 4.

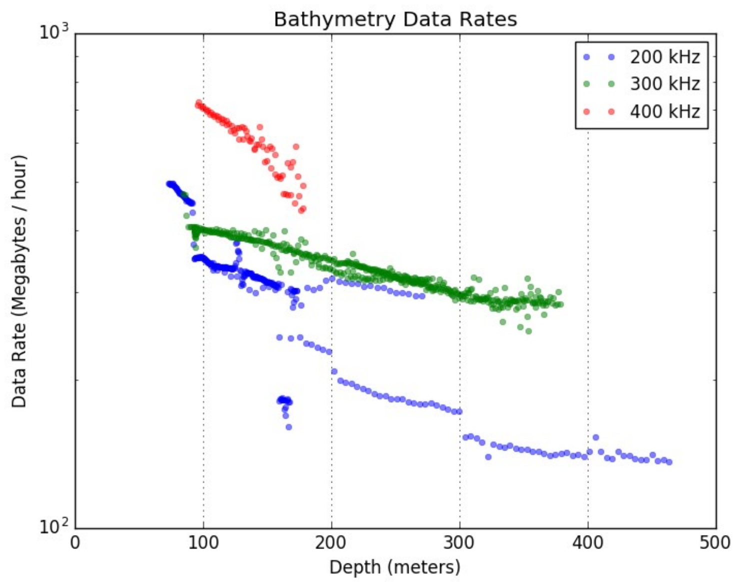


Figure 4 - Data collection rates for the EM2040 without water column data.

The EM2040 data collection rates with water column are shown in Figure 5.

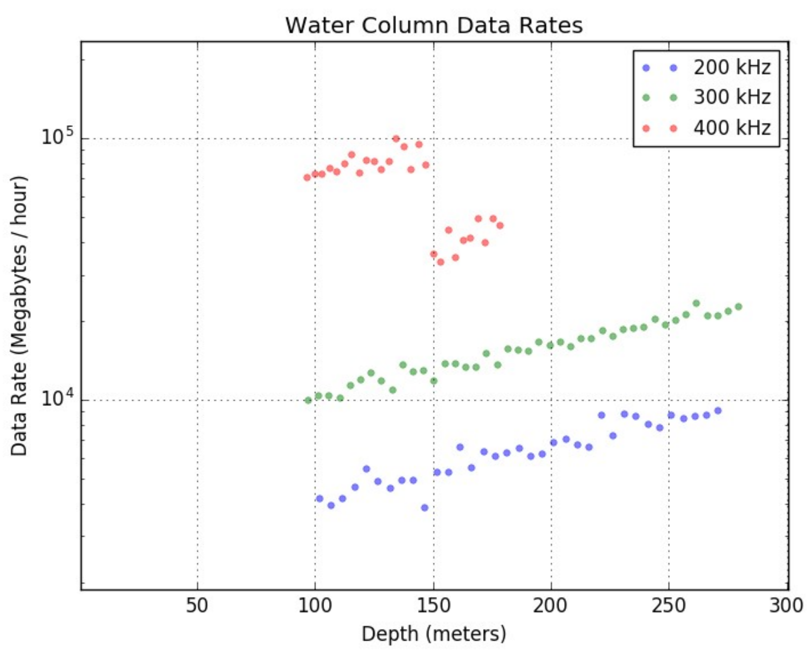


Figure 5 - Data collection rates for the EM2040 with water column data.

The EM710 data collection rates without water column are shown in Figure 6.

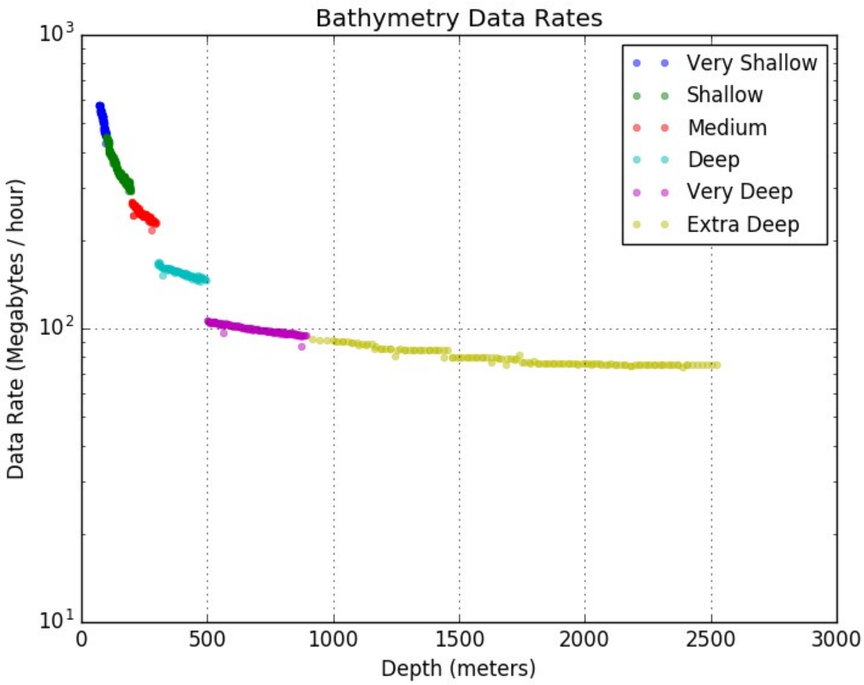


Figure 6 - Data collection rates for the EM710 without water column data.

The EM710 data collection rates with water column are show in Figure 7.

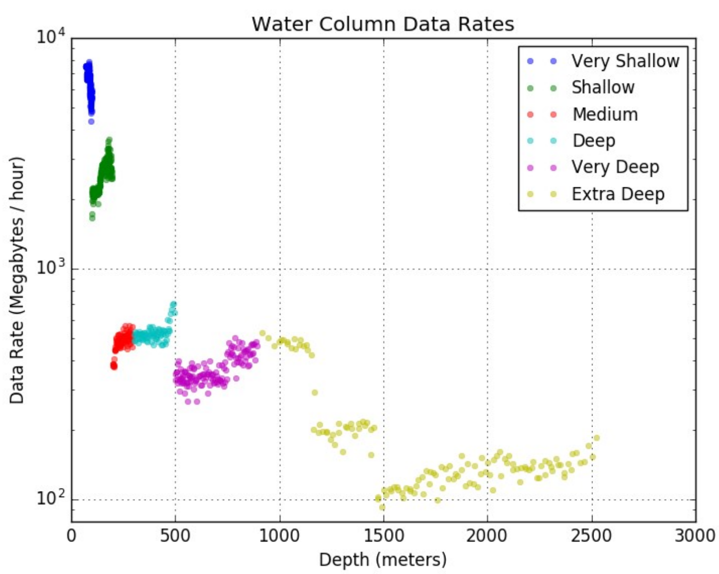


Figure 7 - Data collection rates for the EM710 with water column data.

3.3 Operational hazards

No current environmental or safety regulations or hazards restrict use of this multibeam echo sounder.

3.4 Determine user configurable system settings

The user configurable settings are as expected from past experience and relative to the SIS manual for an EM710 MKII and EM2040.

The EM2040 has an additional setting that had previously not been tested. It is possible to change the type of seafloor detection to "Min Depth", which allows for the better capture of small targets in the water column. The effects of this are discussed further in section 6.4.

4 Configuration

4.1 Sonar installation parameters

4.1.1 Vessel Survey and Reference Frames

Because *Thomas Jefferson* has two Kongsberg multibeams, the configuration successfully used on other platforms (i.e. setting the system reference point at the transmit array) could not work for both systems with a single POS/MV system. Because of the dual multibeam installation and only one possible primary reference point, the reference point was placed top dead center of the IMU, and all angular offsets were defined in the IMU frame.

Both of the EM710 transducers, RX and TX, are mounted in what Kongsberg considers a "forward" configuration. However, both of the EM2040 transducers are in what Kongsberg considers a "reversed" configuration. While this is not expected to cause problems with the current post processing software, historically the reversed configuration has caused complications and is worth noting.

The values used for lever arm offsets and angular rotations were based on the information provided by IMTEC, the survey company contracted by Kongsberg to conduct the vessel offset survey (included in appendix). Tables were provided for the ship reference frame, the IMU reference frame, the EM710 transmitter reference frame, and the ORU reference frame. The raw survey x-y-z locations in the survey reference frame were also provided. While the IMU reference frame table was used to describe all offsets and angles for the vessel configuration, the output from the IMU itself is rotated by the patch test values in SIS to bring it into alignment with the surveyed IMU frame.

While alongside in Norfolk an investigation into the vessel waterline using the draft marks, the vessel ellipsoid height, and a hull mounted sutron gauge was undertaken. A description of this work and results can be found in the appendix. In short, we validated that all methods of obtaining draft were consistent within their precision and that the bubbler gauge was the most precise.

The ship's underway settlement was also estimated while underway in Chesapeake Bay using ellipsoid relative techniques in HSTB's AutoQC tool. These results were comparable with past dynamic draft tests.

4.1.2 Data Flow Configuration

The data flow for a Kongsberg multibeam is multilayered. Multibeam data moves from the TRU to the SIS acquisition workstation. Data can be sent directly from SIS or from two other Kongsberg programs on the SIS workstation to an external client. While this flexibility provides many different options for configuration, it can also be confusing and easily confounded. The approach taken for this installation was mixed. The Kongsberg program, DataDistrobution.exe, was used to forward the multibeam data from the workstation to Hypack. This program has been designated to autostart when the SIS workstation is booted through the Windows Startup folder and must be allowed to run in the system tray or in the background at all times. If this program is closed, data will not be delivered to Hypack. Sound speed packets were sent from a lower level data distribution program to Velocipy.

The survey system was configured as described in Figure 8.

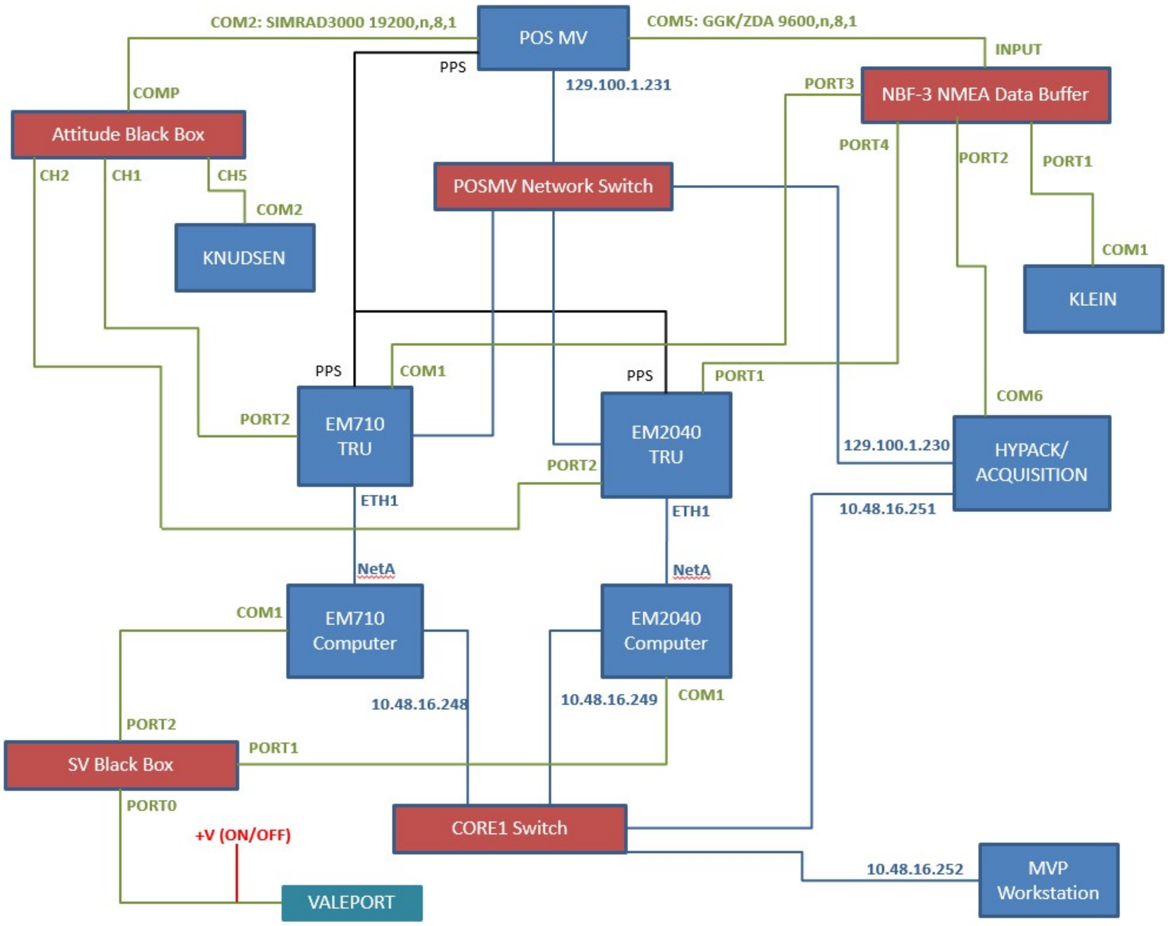


Figure 8 - The Thomas Jefferson survey system configuration as of the acceptance cruise.

Water column logging through SIS on both EM systems is licensed for the *Thomas Jefferson*. When water column is logged a separate raw *.wcd file containing water column records is produced. In addition, this file contains the attitude, position, system settings, installation parameters, and sound speed profiles. While these records are duplicates of some of the bathymetry file contents, these records make the independent use of the water column data easier as no pairing or merging between the *.all and *.wcd files is necessary.

A trigger cable to force the EM2040 to trigger from the EM710 transmit was built and installed by ship personnel as the request of the acceptance team. Triggering in this fashion causes the two systems to ensonify the same piece of the seafloor which is valuable to multi-frequency backscatter work. Enabling the trigger is completed within the EM2040 SIS software.

4.2 Ancillary equipment setup

4.2.1 Position and Attitude

The POS M/V was configured to send navigation (NMEA INGGK string) and attitude (Simrad 3000 (Tate-Bryant)) through serial cables to the TRU for each multibeam though unbuffered serial data splitters. An Ethernet connection from the POS M/V to each TRU was included for attitude velocity. The POS M/V lever arms and rotations were configured with the IMU as the reference point as described in 4.1.1. The POS M/V was checked to confirm proper connection to the primary / secondary antennas, and MarineStar support remained as previously configured. Position and attitude were compared between SIS and the POS M/V and were found to be equivalent. The POS M/V firmware for the PCS and GNSS cards could not be updated because the hardware was no longer under an Applanix maintenance contract.

4.2.2 Surface Sound Speed

There are three possible sources of surface sound speed aboard *Thomas Jefferson, however* both multibeams were configured to only receive data from the hull mounted Valeport sound velocity sensor during this cruise. The Valeport surface sound speed probe was configured to send an AML message directly to SIS and was confirmed to work as expected. A benefit of using the Valeport is that it is mounted on a seacock such that it can be retracted and removed for easy servicing (Figure 9). In addition to the Valeport, the ship has a TSG and a Reson sound speed sensor mounted in a flow through tank.

Figure 9 – The Valeport in the retracted positon as mounted on a closed seacock. When the value is open the sensor is deployed by pushing down on the black handles.

4.2.3 Profiling the Physical Characteristics of the Water Column

An MVP with a CTD sensor was used during acceptance work. The sensor was compared with a recently calibrated Seabird CTD, as well as being compared with values from the Valeport surface sound speed sensor, located at hull depth, and found to be working properly.

Velocipy was configured to send new casts directly to SIS for both multibeams and to receive a message back noting that the cast was accepted by SIS. All cast extensions were made in Velocipy using either a deeper cast or the World Ocean Atlas.

Unfortunately, Casttime was not functioning during the cruise. While Casttime was configured and working before leaving port, some configuration change that remained undetermined caused Casttime not to receive cast information from the MVP. Had Casttime been running, some of the problems experienced during this cruise may have been alleviated. It was expected that ship personnel would resolve this problem at a later date.

4.2.4 Hypack

Hypack was configured to accept data from SIS for real time display and communication with the bridge only. For these tests, all multibeam data were logged through SIS. We recommend that SIS be used for all future operational data logging as well.

4.2.5 Vertical control

Generally, the vertical reference for acceptance work was either the real time water level or the ellipsoid depending on the requirement for a consistent vertical reference for the seafloor depth. The ITRF 2008 ellipsoid was realized through MarineStar integration with the POS M/V which was recorded both in the POS M/V files and in the Kongsberg *.all files. Where a comparison to previous surveys was required, VDatum was used to shift from the ellipsoid to the applicable datum.

5 Alongside Testing

5.1 User interface and system control

The user interface and system controls for the EM710 and EM2040 operated the same as for previous versions of SIS. SIS 4.3.2 was installed on the EM2040, and SIS 4.3.0 was installed on the EM710. Minor changes to SIS are EM model specific, and these two versions are essentially the same.

5.2 System health self-tests

SIS Built In Self Tests (BIST) of all types were performed for both systems, including the extended tests available through the TRU. While all BIST tests passed, a single receiver channel (number 52) on the EM2040 showed a significantly different response, indicating a possible broken channel.

5.3 Evaluate stave data

See the discussion of BIST tests in 5.2.

5.4 Backscatter quality assessment

Backscatter quality was not assessed while alongside. Please see 6.6 for a discussion of backscatter assessment and normalization while underway.

6 Underway Testing

6.1 Patch Test

Patch testing was attempted in two separate locations but completed for both systems over Tom's Canyon, approximately 100 nm SE of New York City. We attempted to complete the patch test of the EM2040 over the wreck of the Bow Mariner. Because the wreck tests lead to inconclusive results the ship moved to Tom's Canyon and patch tested both systems simultaneously. This location had been used previously for patch testing the EM710 from NOAA Ship *Nancy Foster*. The 60 meter drop from 120 meters to 180 meters proved to be a good target for pitch and yaw lines. Roll lines were conducted on top of the shelf just above the canyon, and confirmation lines were run across the canyon in a deeper section. Patch test values are described for both systems in Table 1.

Table 1 - Patch test values for both multibeams.

All values are in degrees	EM2040	EM710
Roll	0.07	0.02
Pitch	-0.05	-0.05
Yaw	0.70	0.05

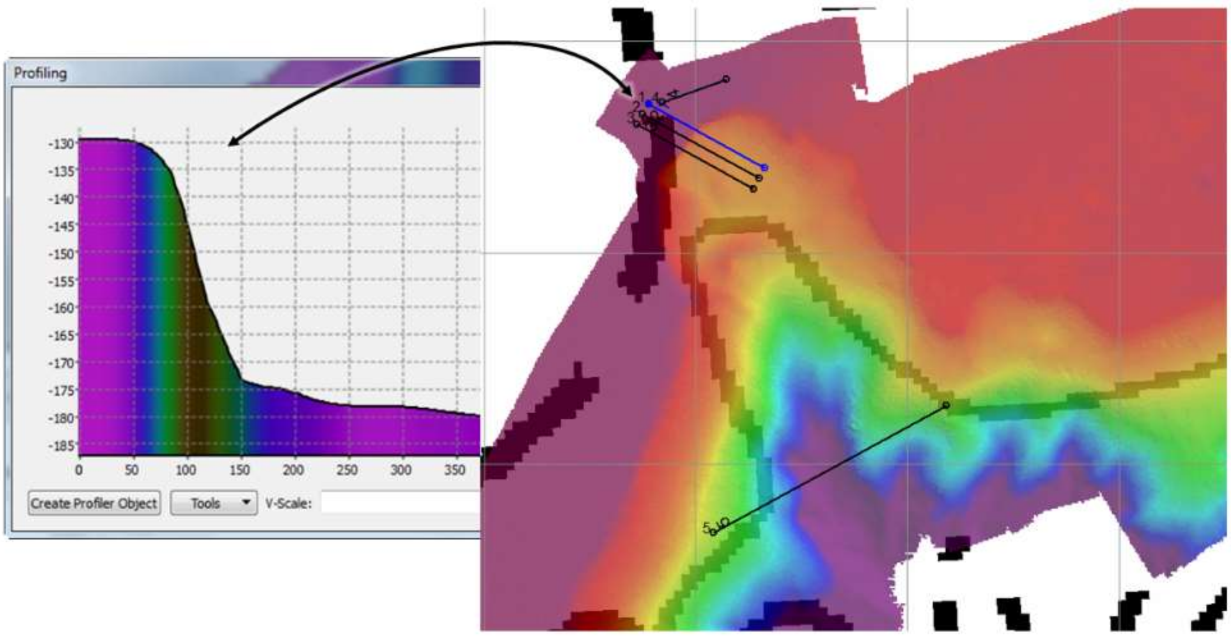


Figure 10 - The patch test lines at Tom Canyon. On the left is a profile of the pitch line. On the right is an overhead view of the relief and patch test lines. Line 2 is pitch, 1 and 3 were for yaw, and 4 was for roll. Line 5 is the confirmation line, with the maximum depth being at 450 meters.

We calculated an attitude time delay of 10 ms using the correlation of roll rate with swath slope artifact as described in [4] using transit data from the EM2040 acquired after the Tom's Canyon patch test. There were significant artifacts in the bathymetry as described in section 6.4, which reduce confidence in this estimate. EM710 noise was such that no estimate could be made with the same set of lines. Subsequent work to improve the estimated time delay from the EM2040 data increased the estimate to 11 ms (Figure 11) with a reported uncertainty of 2 ms at two standard deviations from the covariance matrix used for line fitting. Similar work to extract a time delay for the EM710 resulted in similar values to the EM2040. This time delay is entered in to SIS for both multibeams and the SIS recorded attitude data time stamp is shifted accordingly for post processing. This time delay is different than the 14 ms offset found with both NOAA ships *Rainier* and *Fairweather* but is sufficient until the outer beam artifacts are removed and a better estimate can be made. The root cause of this time delay on this and other systems remains unknown.

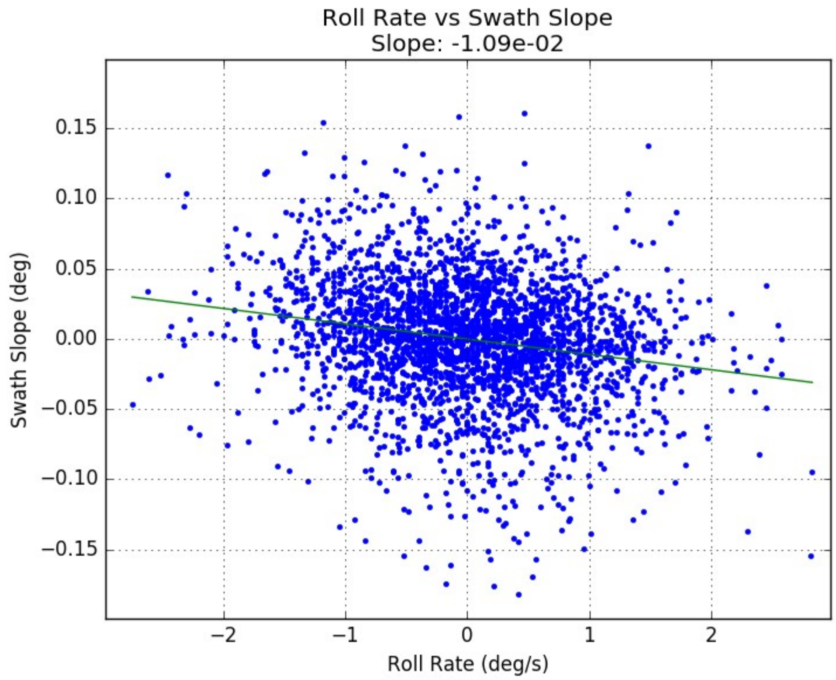


Figure 11 - Roll Rate to Swath Slope Correlation for the EM2040. Green line is a linear fit.

6.2 Acquire Reference Data Set

Three reference datasets in different depths were acquired for the EM710. One of these locations was used for the EM2040 as well. These data are used to check for bathymetric biases across the swath by comparing survey data with a dense reference surface. The IHO uncertainty standards (and similarly the NOAA specification) contain both a depth dependent and depth independent error component; the depth independent part (*a* in Equation 1) is intended to account for error sources such as vertical control and draft measurement, the depth dependent factor (*b* in Equation 1) accounts for integration, environmental, and echo sounder performance .

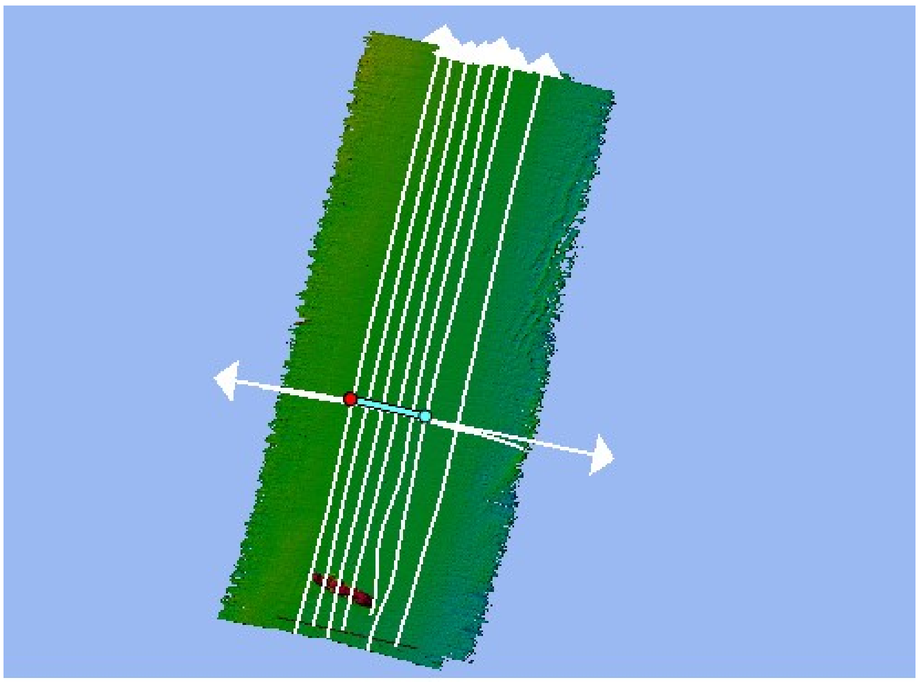
Equation 1: Vertical uncertainty limit equation from both IHO and NOAA Specifications.

$$Uncertainty\ Limit = \sqrt{(a^2) + (b * d)^2}$$

Because of the nature of these tests, the depth independent error parameters were not much varied, so it is more appropriate to evaluate the performance only against the depth dependent component (i.e. the 'b' parameter). For both IHO order 1 and NOAA Specifications, this is 1.3% of water depth.

EM2040 ACCURACY TESTING

The area to the north of the wreck of the Bow Mariner was used for the reference surface. This area is flat and generally ~75 meters deep (Figure 12). 200 kHz, 300 kHz and 400 kHz modes were tested. Weather was 15 to 20 knots with seas 2 to 3 feet and with swells also 2 to 3 feet. Current was from the north causing a set of approximately 6 degrees of heading when on line. A number of artifacts were observed during these tests. The combined effect of which obscured identification of any one problem. One of these problems was variable sound speed (Figure 13) at depth during testing. This variability may have been caused by the propagation of internal waves. This impacted the performance of EM2040 during this test, causing a larger apparent uncertainty than would be experienced during more stable oceanographic conditions. Another artifact was a periodic, but non-motion correlated, leeward outer beam artifact that is still being investigated. This artifact is discussed in more detail in section 6.4. The reference surface was created from the object detection lines filtered to remove outer beam noise. This analysis was conducted by accumulating data from several lines with opposing headings.



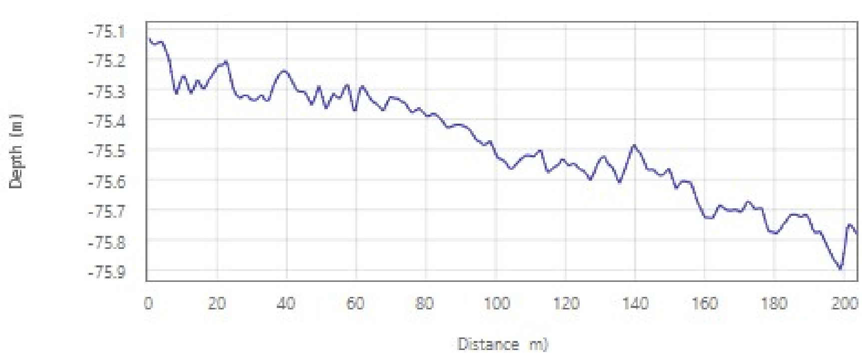


Figure 12 - The accuracy test site at the Bow Mariner. Accuracy data were extracted along the profile (blue line in top, plot in bottom). The wreck can be seen as red in the bottom of the surface. Depths are relative to mean lower low water.

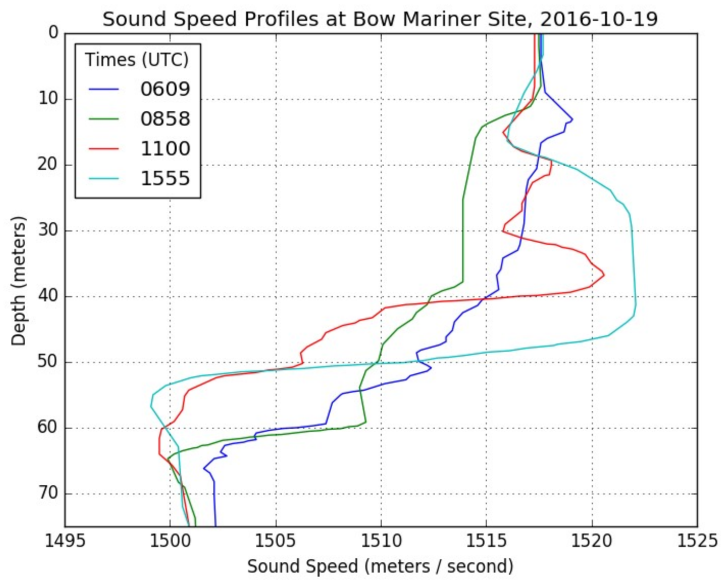


Figure 13 – Sound Speed Profiles at the Bow Mariner site during object detection and accuracy testing. There are significant changes in these casts between 10 meters and 60 meters of water depth.

The comparison between these data was conducted on the ellipsoid in Qimera 1.3.6.

The 400 kHz mode had a mean bias of less than 0.3% of water depth, which equates to 0.23 meters in 75 meters of water. While the pulse length was set to adjust automatically, during the 400 kHz tests the pulse length was 107 microseconds with a CW pulse. A sound speed artifact is evident in the outer swath due to the dynamic oceanographic conditions. Soundings fell within 0.6% of the mean difference at two standard deviations. Note the maximum swath angle for the 400 kHz mode is restricted 60 degrees on each side. While these results meet expectations, these statistics should improve in more ideal oceanographic conditions.

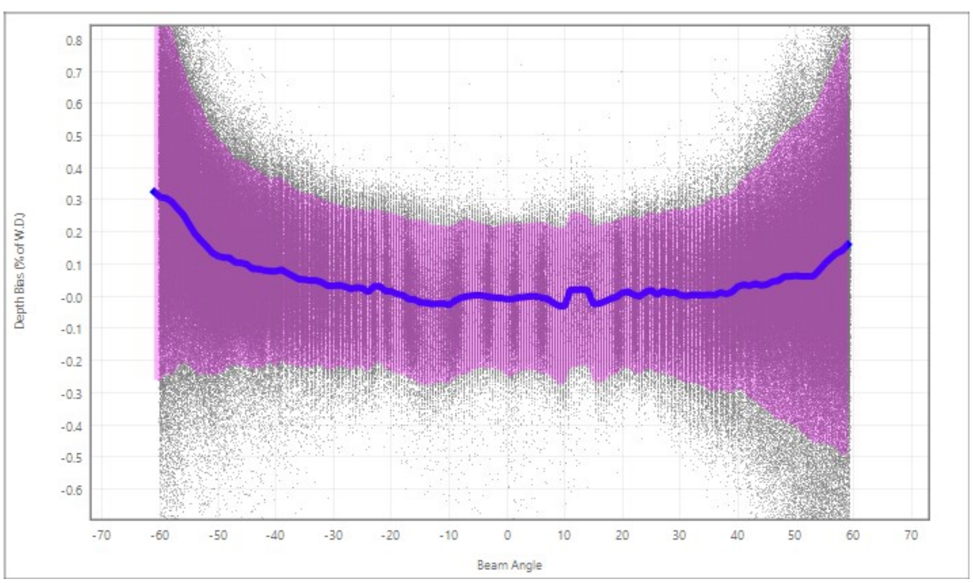


Figure 14 – EM2040 400 kHz accuracy results as a percent of depth. The blue line is the mean difference between the reference surface and these data. The pink region is 2 standard deviations from the mean. IHO Order 1 is 1.3% for this location.

The 300 kHz mode had a mean bias at nadir of less than 0.1% of water depth, which equates to 0.08 meters in 75 meters of water. While the pulse length was set to adjust automatically, during the 300 kHz tests the pulse length was 370 microseconds with an FM pulse. A sound speed artifact is evident in the outer swath due to the dynamic oceanographic conditions. Soundings approximately within 1.0% of the mean difference at two standard deviations inside a 130° opening angle. While these results meet expectations, these statistics should improve in more ideal oceanographic conditions and once the additional artifact is resolved.

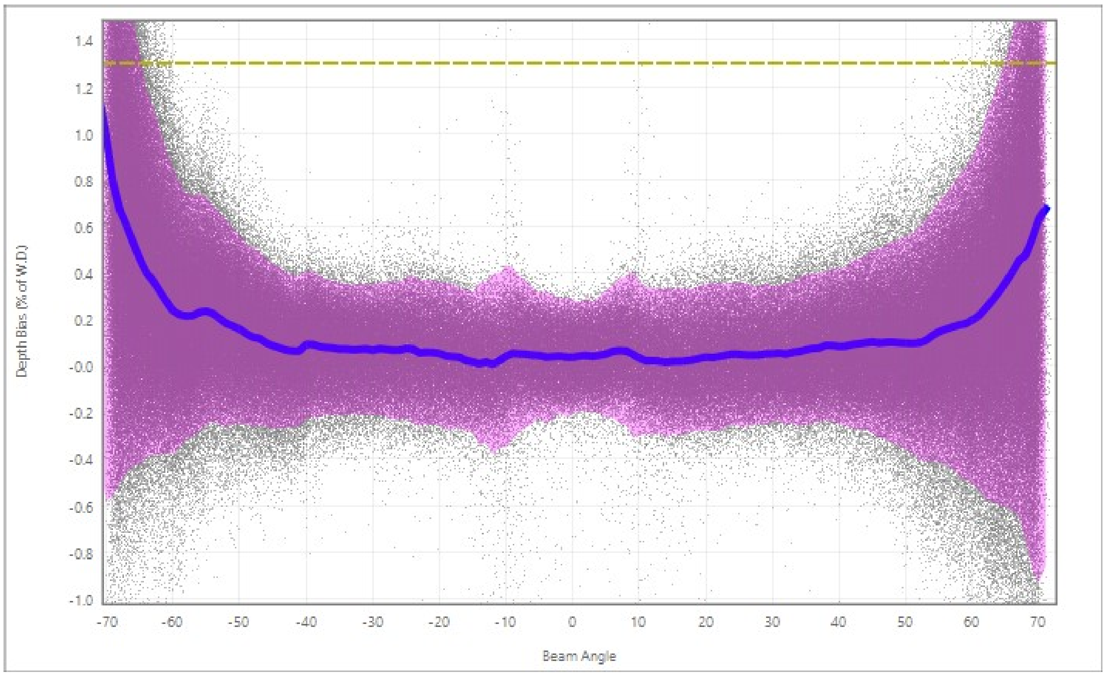


Figure 15 – EM2040 300 kHz accuracy results as a percent of depth. The blue line is the mean difference between the reference surface and this line. The pink region is 2 standard deviations from the mean. IHO Order 1 is 1.3% for this location.

The 200 kHz mode had a mean nadir bias of less than 0.1% of water depth, which equates to 0.08 meters in 75 meters of water. The pulse length was set to adjust automatically, and during the 200 kHz tests the pulse length was between 431 and 517 microseconds with an FM pulse. A sound speed artifact is evident in the outer swath due to the dynamic oceanographic conditions. Soundings were approximately within 1% of the mean difference at two standard deviations and inside 130° opening angle. While these results meet expectations, these statistics should improve in more ideal oceanographic conditions and once the additional artifact is resolved.

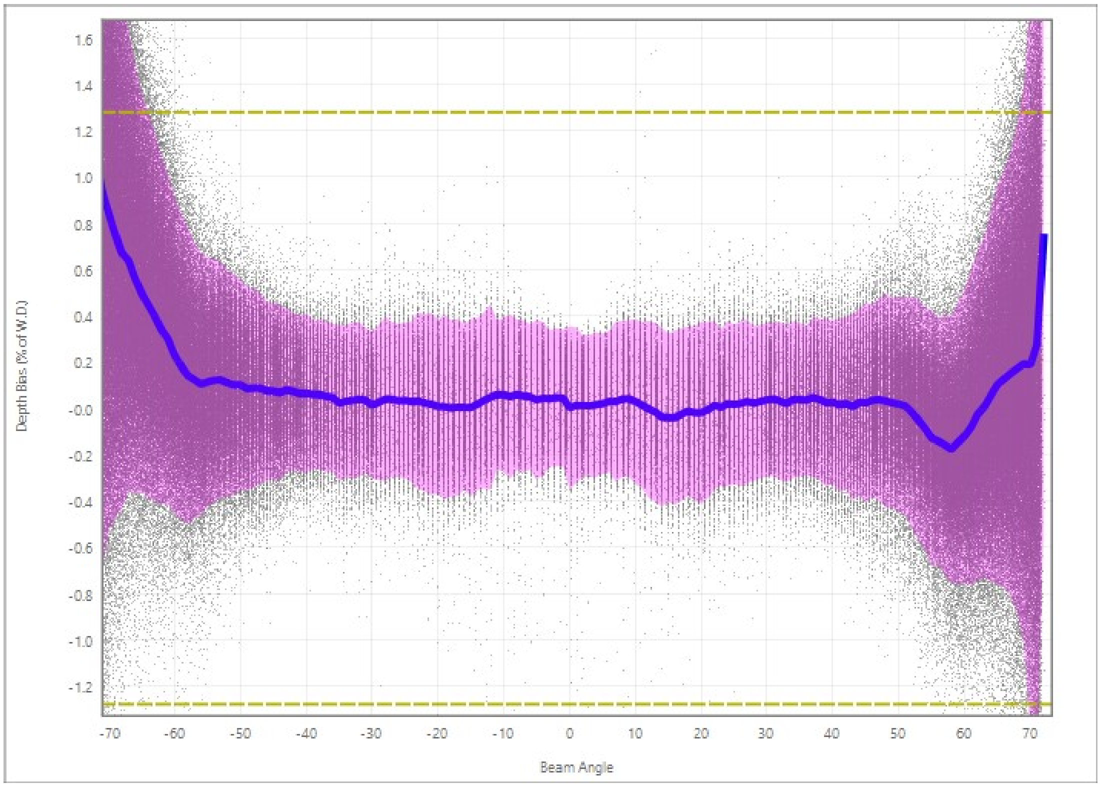


Figure 16 – EM2040 200 kHz accuracy results as a percent of depth. The blue line is the mean difference between the reference surface and this line. The pink region is 2 standard deviations from the mean. IHO Order 1 is 1.3% for this location.

EM710 ACCURACY TESTING

Three separate areas were used for accuracy testing of the *Thomas Jefferson* EM710 MKII. The modes Shallow, Very Shallow, and Medium were tested at the same Bow Mariner site used for the EM2040. Sound speed problems as discussed in the EM2040 section for the Bow Mariner site are also present for the EM710. The EM2040 reference surface was used for the test, and was constructed from the EM2040 object detection data as described previously. The 70 meter mean depth for this area would normally be collected in Very Shallow mode which is used by the EM710 MKII systems in automatic mode for depths between 0 and 100 meters.

Flat areas in the proper depths suitable for accuracy testing of the deeper modes are rare within a reasonable steaming distance from Norfolk, VA and also not in the Gulf Stream. Areas near the extinction line and just sound of Hudson Canyon were used for these deeper modes. These sites had less than a 3° slope that ran across the reference surface. Because there were fishing vessels in the area and this work was conducted at night, the MVP was not towed. Medium and Deep modes were tested at more than one location to help provide some continuity between the locations.

Deep and Medium mode were tested in approximately 200 meters of depth (Figure 17). A CTD to 170 meters was taken at the medium depth site upon arrival. The 200 meter mean depth at this site would normally be collected in either Shallow mode, optimized for depths between 100 to 200 meters, or in Medium mode, good from 200 to 300 meters water depth.

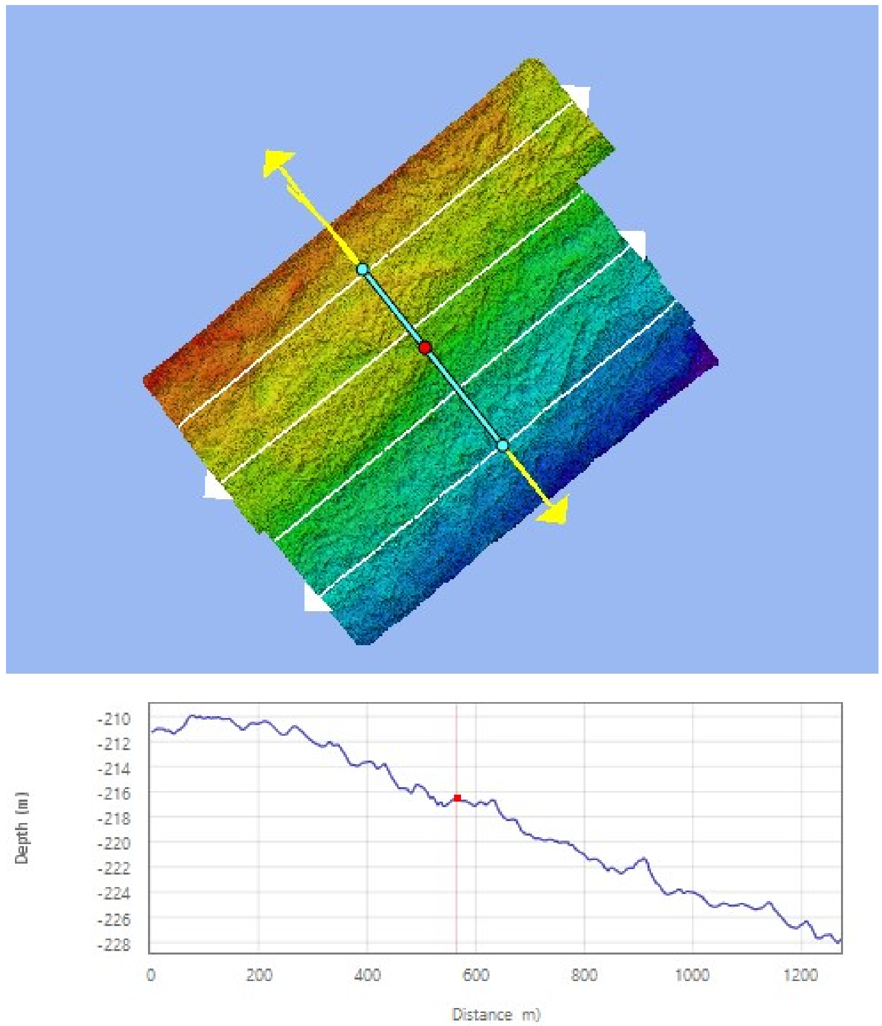
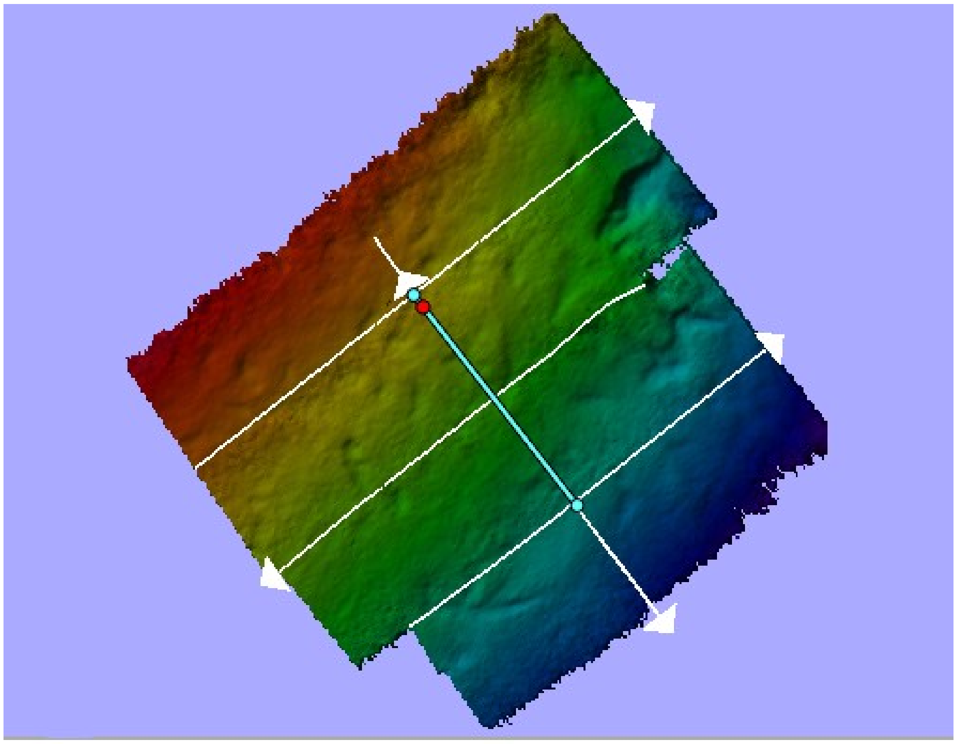


Figure 17 – The EM710 medium depth accuracy test site. Accuracy data were extracted along the profile (blue line in top, plot in bottom). Depths are to the ellipsoid.

Deep, Very Deep and Extra Deep were tested in approximately 550 meters of water (Figure 18). A CTD cast to a depth of 300 meters was taken in 600 meters of water with the extended point being interpolated linearly from the last section of the water mass. The 550 meter mean depth for this area would normally be collected in Very Deep mode which is optimized for depths between 500 and 1000 meters.



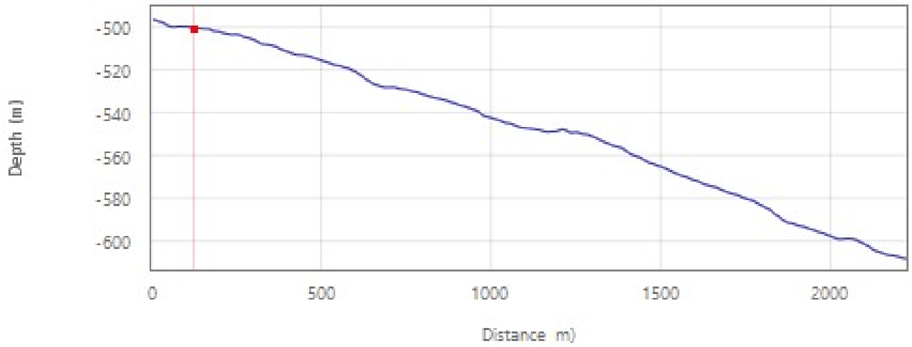


Figure 18 - The EM710 deep accuracy test site. Accuracy data were extracted along the profile (blue line in top, plot in bottom). Depths are to the ellipsoid.

Table 2 - A summary of the test location for each mode.

Mode	Shallow Site	Medium Site	Deep Site
Very Shallow – Single & Dual Swath	✓		
Shallow – Single & Dual Swath	✓		
Medium – Dual Swath	✓	✓	
Medium – Single Swath		✓	
Deep – Dual Swath		✓	✓
Deep – Single Swath		✓	
Very Deep – Single Swath			✓
Extra Deep – Single Swath			✓

Very Shallow mode was tested in both single and dual swath with each displaying the same characteristics. Figure 19 shows the results for dual swath mode.

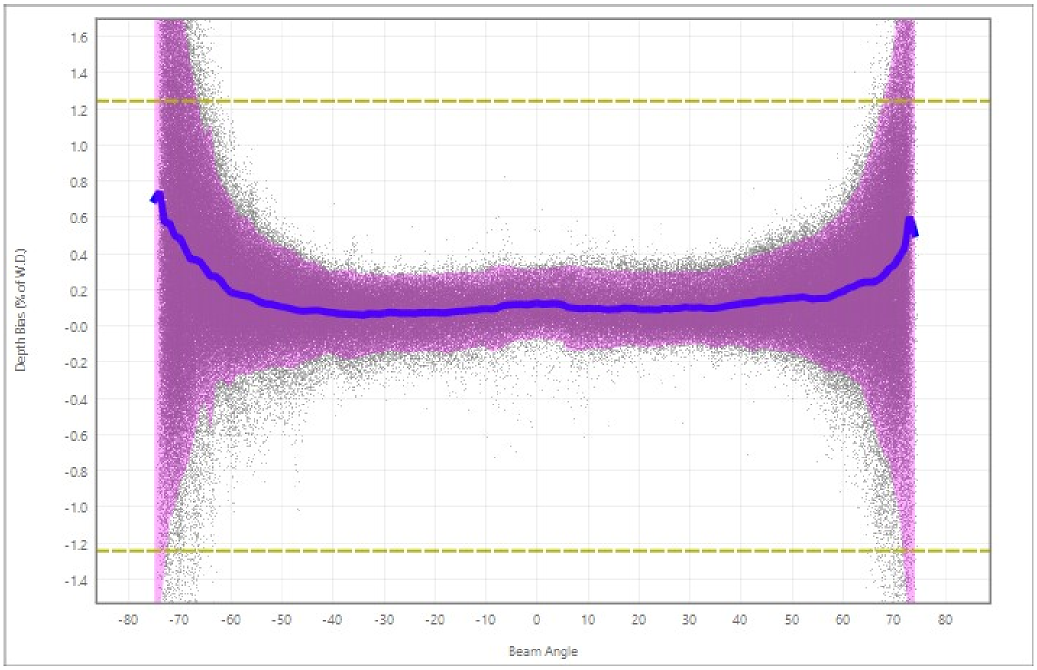


Figure 19 - EM710 Very Shallow Dual Swath mode accuracy results as a percent of depth. The blue line is the mean difference between the reference surface and this line. The pink region is 2 standard deviations from the mean.

Shallow mode was also tested in both Single and Dual Swath in the same location with similar results. Some noise is evident in the near-nadir region for this mode (Figure 20).

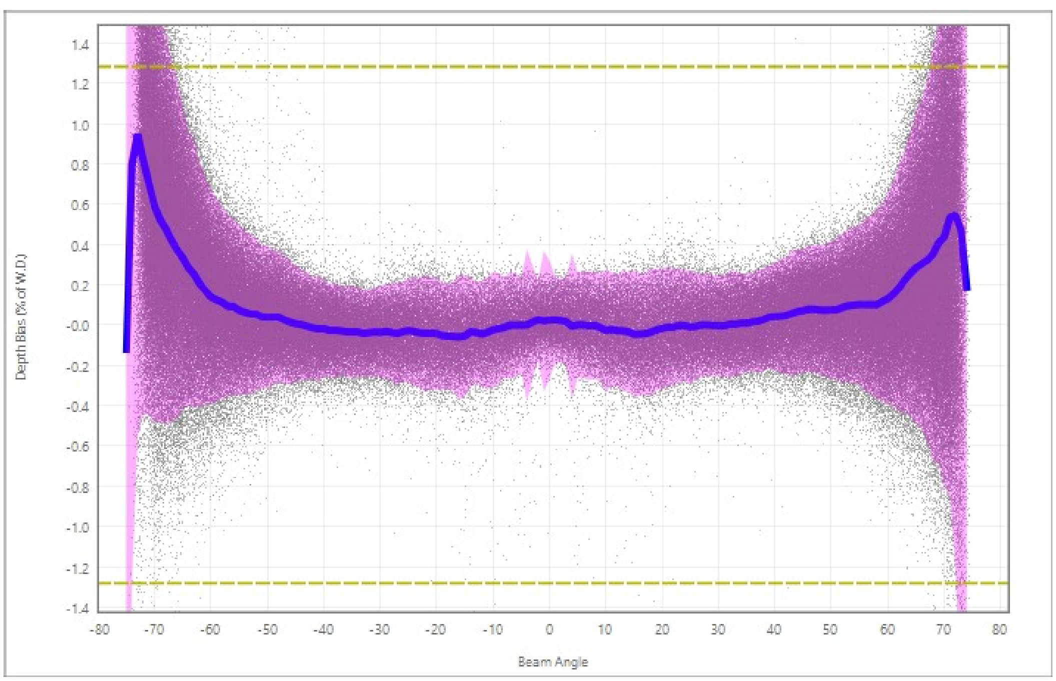


Figure 20 - EM710 Shallow Dual Swath mode accuracy results as a percent of depth. The blue line is the mean difference between the reference surface and this line. The pink region is 2 standard deviations from the mean.

Medium mode was tested at both the Bow Mariner (shallow) site and at the medium depth site (Figure 21, Figure 22). The results from these two locations were comparable, with more noise near nadir evident at the shallower location. To reduce the effect of the sound speed artifact at the medium site, we filtered the crossline to within +/- 15 degrees of nadir and generated the reference surface with these filtered lines. We then used the main scheme lines to compare to the reference surface. Because the main scheme lines were acquired closer to the time of the cast, they had less of an artifact. By restricting the data collected later (cross lines) to the near nadir region and using the data collected closer in time to the cast (main scheme lines) the effects of sound speed are reduced. In some cases there was significant nadir noise that was not displayed directly in the plot, but was reflected in the standard deviation (pink) part of the plot.

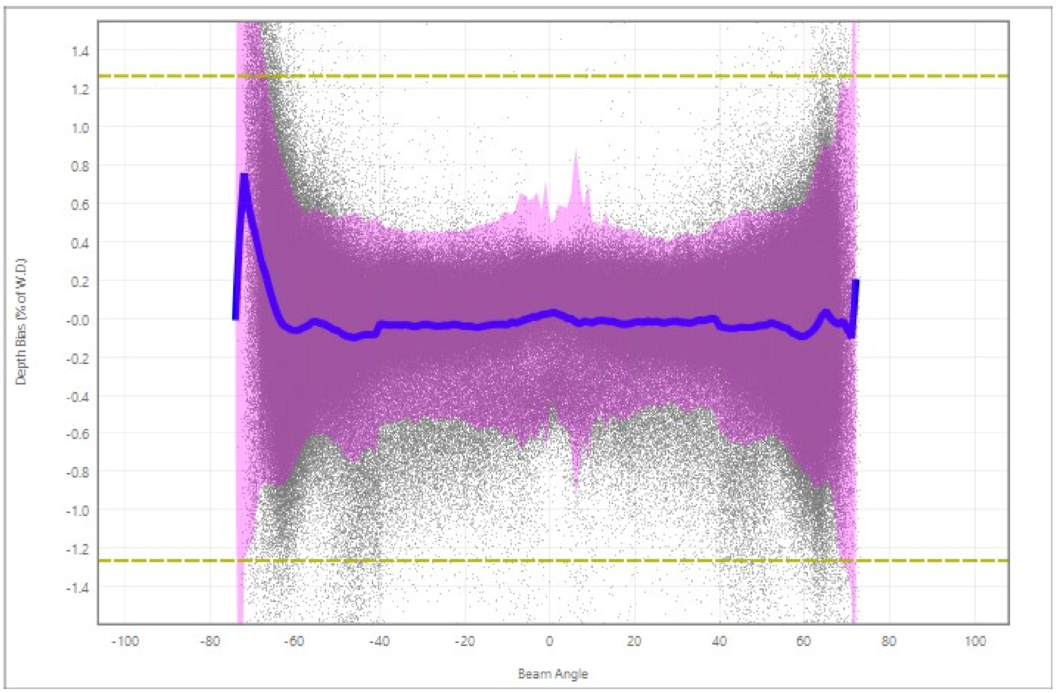


Figure 21 - EM710 Medium Dual Swath mode accuracy results as a percent of depth at the Bow Mariner site (75 meters). The blue line is the mean difference between the reference surface and this line. The pink region is 2 standard deviations from the mean.

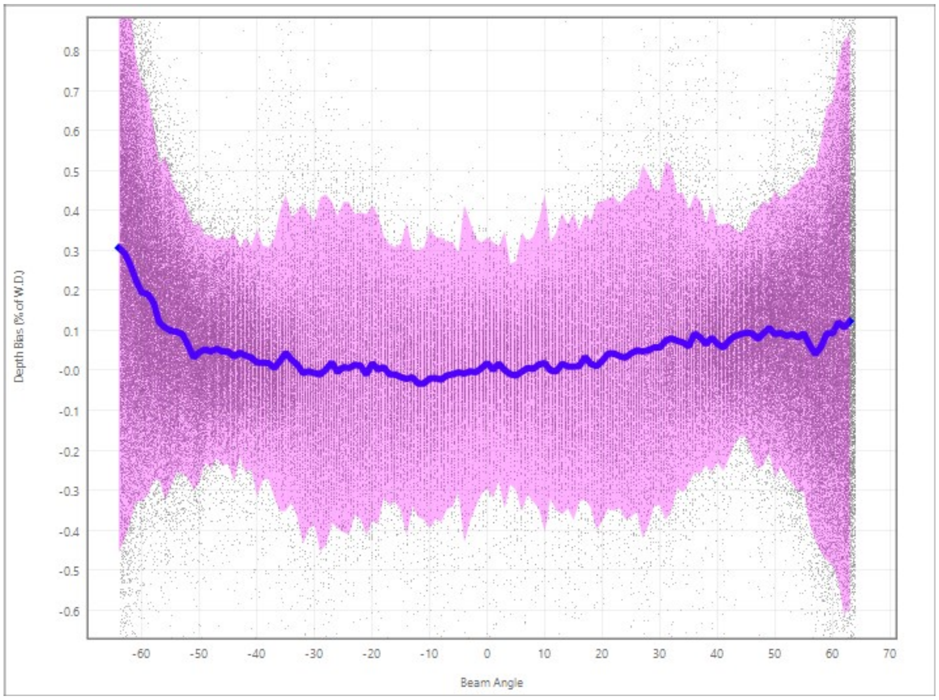


Figure 22 - EM710 Medium Dual Swath mode accuracy results as a percent of depth from the medium depth site (200 meters). The crosslines have been used to make a small nadir-only surface and compared to the main scheme lines. The blue line is the mean difference between the reference surface and this line. The pink region is 2 standard deviations from the mean.

Unfortunately, the same approach to reducing the sound speed effects cannot be used for deep mode at the medium depth site since the main scheme lines were collected in medium mode. Deep mode was tested in both Single and Dual Swath modes. Dual Swath mode showed significant nadir noise (Figure 23), while Single Swath mode show a large increase in noise in the starboard sector (Figure 24).

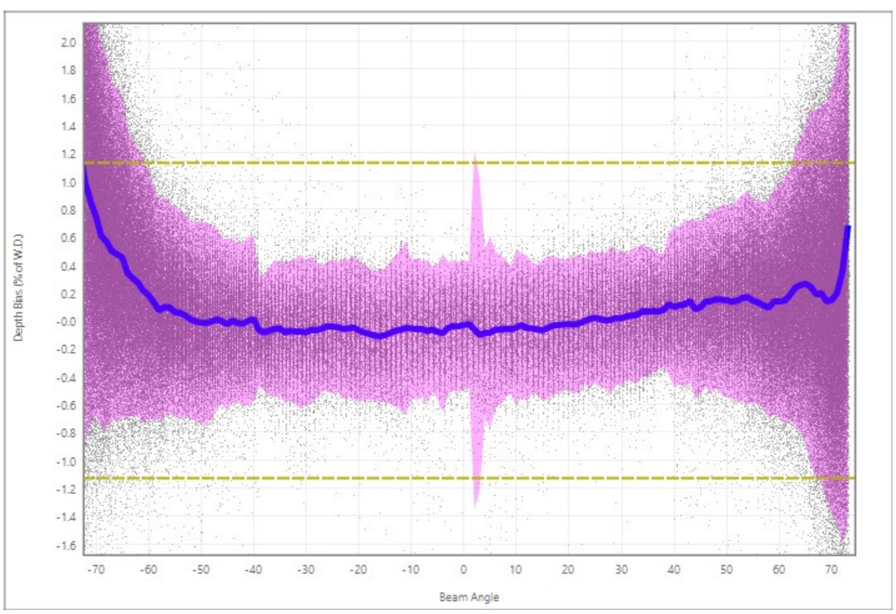


Figure 23 - EM710 Deep Dual Swath mode accuracy results as a percent of depth from the medium depth site (200 meters). The blue line is the mean difference between the reference surface and this line. The pink region is 2 standard deviations from the mean.

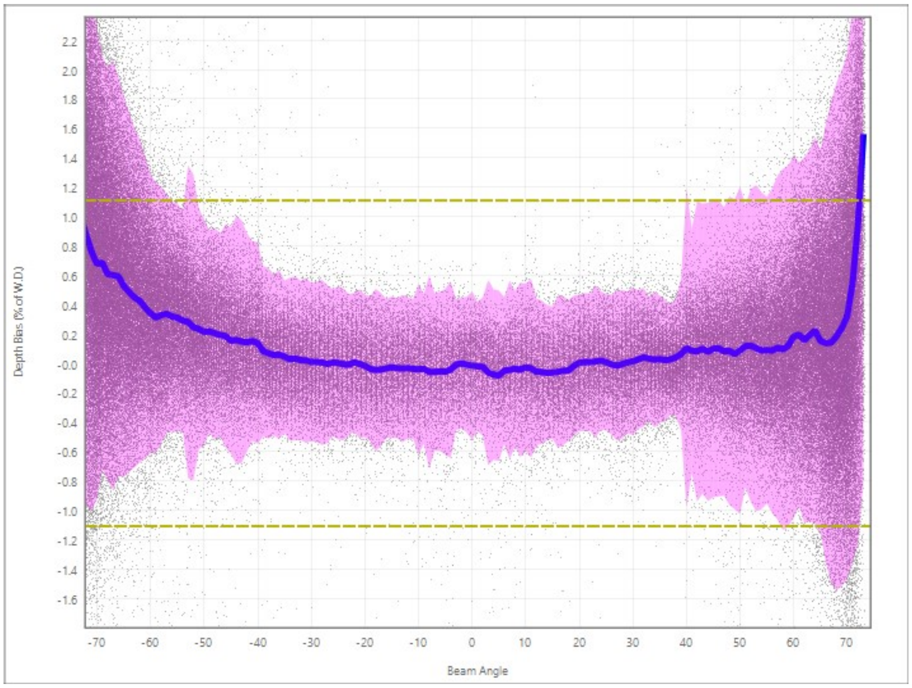


Figure 24 - EM710 Deep Single Swath mode accuracy results as a percent of depth from the medium depth site (200 meters). The blue line is the mean difference between the reference surface and this line. The pink region is 2 standard deviations from the mean. The rapid change at +40 degrees is the port sector boundary.

Very Deep and Extra Deep modes do not have Dual Swath capability and were thus only tested in Single Swath mode. The data were within 1% of water depth at two standard deviations to the mean difference, which equates to approximately 6 meters at this location.

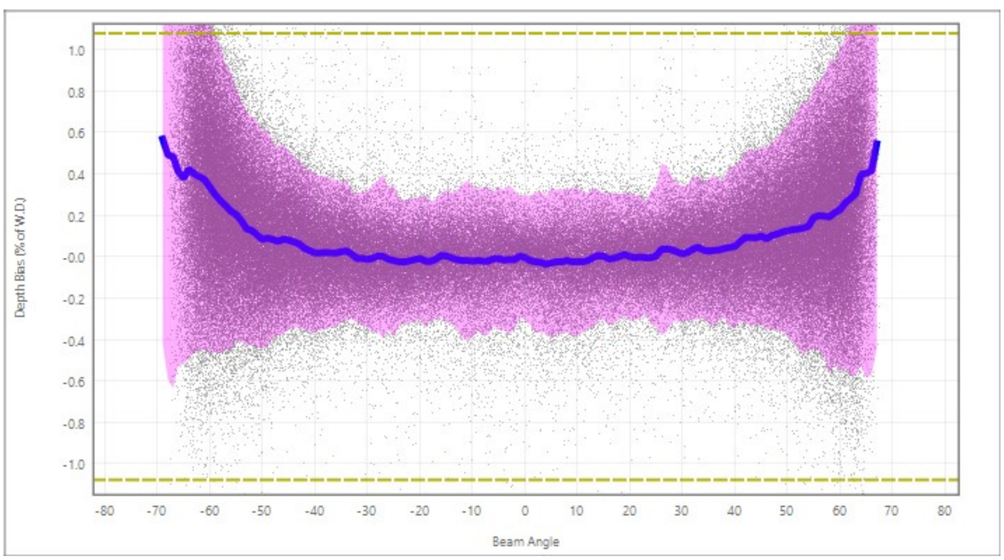


Figure 25 - EM710 Very Deep mode accuracy results as a percent of depth from the deep site (~550 meters). The blue line is the mean difference between the reference surface and this line. The pink region is 2 standard deviations.

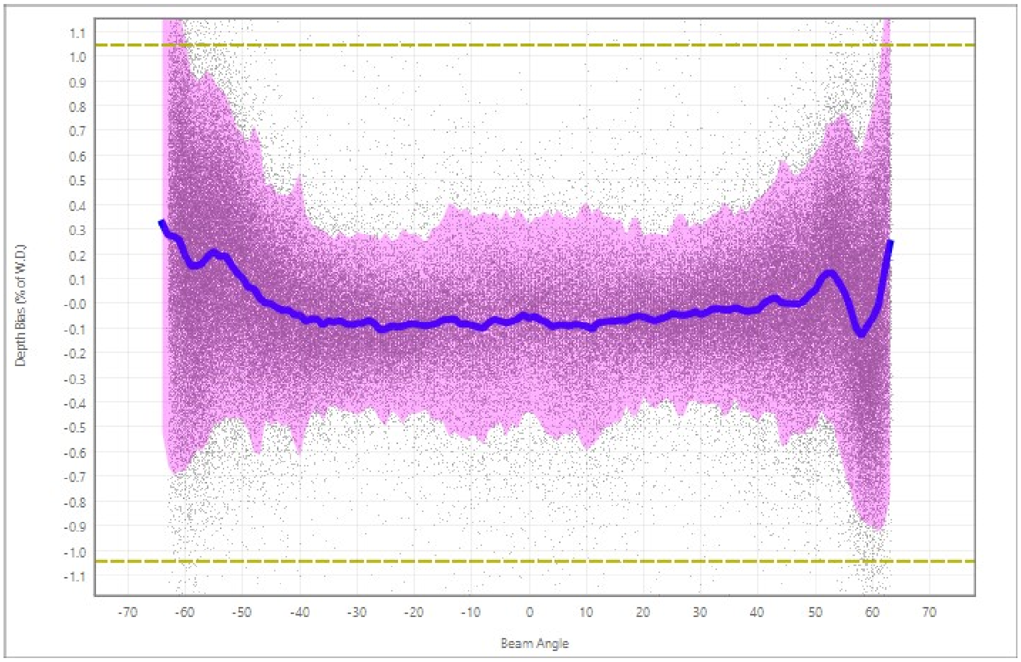


Figure 26 - EM710 Extra Deep mode accuracy results as a percent of depth from the deep site (~550 meters). The blue line is the mean difference between the reference surface and this line. The pink region is 2 standard deviations.

6.3 Noise floor testing

The purpose of noise testing is to assess sources of acoustic interference that may impact data quality. Also, establishing a baseline noise level provides for the opportunity to identify significant changes in the future. Noise floor testing was completed in several locations for different conditions. Tests were conducted using both the BIST RX Noise and RX Noise Spectrum functions in SIS as well as with water column in passive mode. Passive water column is shown as averaged along each beam as a time series of all pings. These data are then also averaged by each beam for each speed. Averaging by beam assumes that noise is at a consistent angle relative to the vertical, and in the case where noise is transducer relative the noise may be smeared across several angles as the vessel rolls. Averaging was completed in the linear domain after data outside of 3 standard deviations was removed from the time series. EM2040 analysis on passive water column is limited to the even pings because the odd pings did not present usable data due to a firmware problem. This problem was reported to Kongsberg and a fix is forthcoming. Only the main engine was used during testing.

A deep test area was chosen at the bottom of the extinction line in 2500 meters of water to minimize the effect of vessel noise reverberating off the seafloor. Both the EM2040 and EM710 were tested at this site. The weather was from the southwest at 15 – 20 knots with seas and swells at 2 – 3 feet. Tests were conducted both into and out of the weather.

Shallow water noise testing was undertaken in two locations. The EM710 shallow area was southwest of the Bow Mariner wreck in a depth of 70 meters and was only conducted going into the weather, which was from the southwest at 15 knots and 2 – 3 feet. EM2040 testing was also conducted in this location and under the same conditions. In addition, noise testing was also conducted for the EM2040 inside Chesapeake Bay during some of which the Doppler Speed log was also active.

These results are presented in the following echo sounder specific sections.

EM2040 Noise Testing

BIST noise tests are governed by preset Kongsberg settings but passive water column is sensitive to user settings. The frequency mode is particularly important as it changes the echo sounder's sensitivity to noise at particular frequencies. Also, the maximum range setting changes the record length, with shorter record lengths opening gaps between water column records where burst noise might occur. In this case the deep water noise testing had a frequency setting of 200 kHz and a record length of 500 meters. The shallow water testing the in Chesapeake tested all frequencies but had a record time equivalent to a 50 meters range scale. The shallow water testing south of the Bow Mariner wreck had a frequency setting of 300 kHz and a record length of 100 meters.

The deep water BIST noise and noise spectrum tests collected into the seas are shown in Figure 27 and Figure 28. No significant change in background noise level with change in engine RPM was identified. Noise levels are generally low across all frequencies. This indicates that the system is limited by internal noise rather than flow noise. As noted in section 5.2, channel 52 appeared not to function correctly. There appears to be low background noise for all EM2040 frequencies as shown by the noise spectrum test.

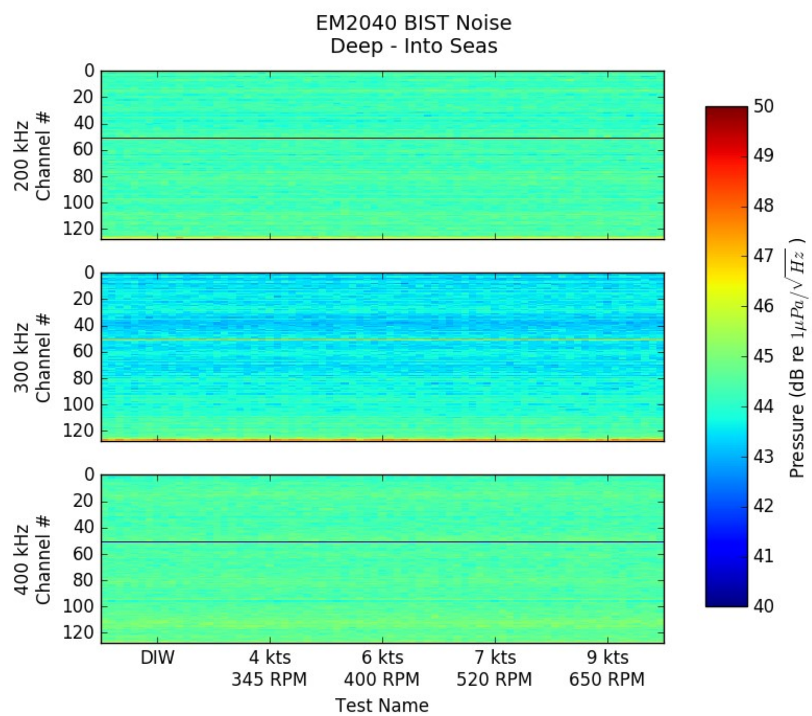


Figure 27 - Deep water BIST Noise tests heading into the seas.

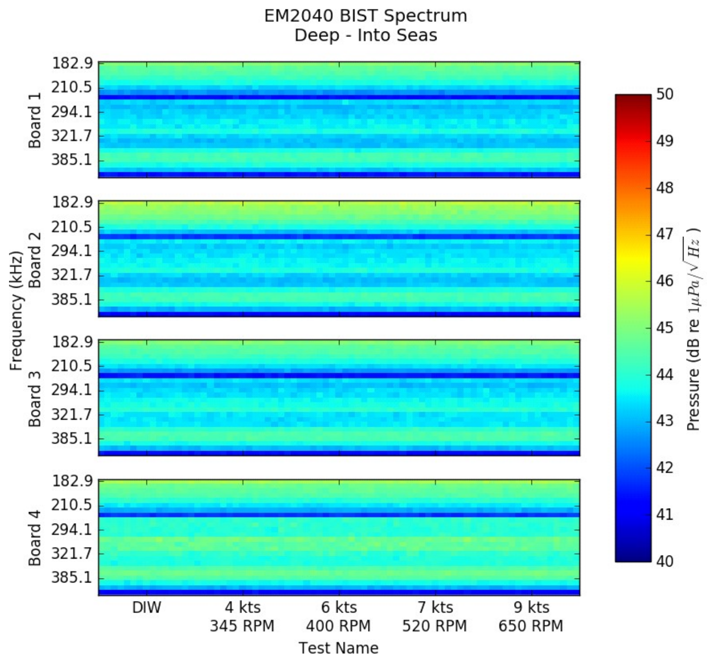


Figure 28 - Deep water noise spectrum tests heading into the seas.

Passive water column was also used to look at the beam formed deep water noise. Figure 29 shows the entire into seas dataset (even pings only) with little identifiable change. When dead in water (DIW) the noise was noticeably higher. Figure 30 shows the data as averaged by beam and by speed. In both figures there is coherent noise at boresight, and therefore transducer relative, and changes beam number as the vessel rolls. If this analysis were conducted by averaging through transducer relative angles rather than vertically stabilized angles (beam numbers) the coherent noise would be even more apparent in the speed relative plot. This coherent noise is likely electronic in origin.

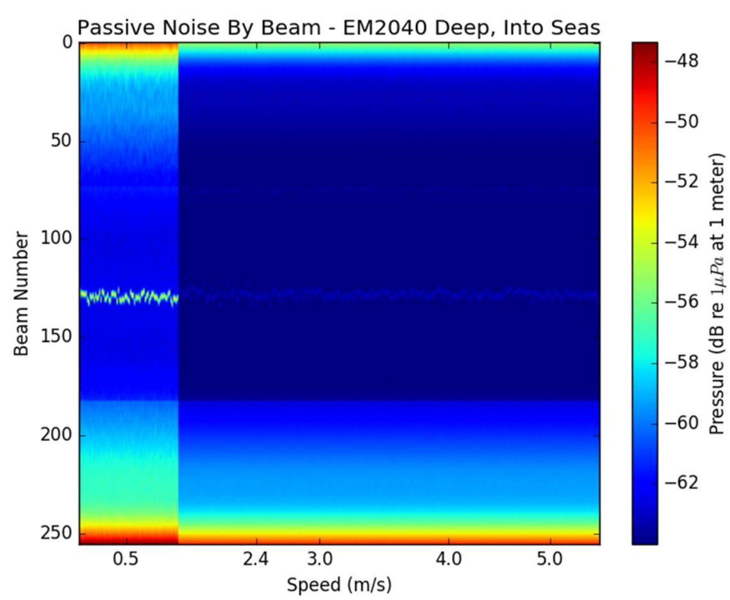


Figure 29 - Deep water noise from passive water column heading into the seas. The EM2040 was in 200 kHz mode.

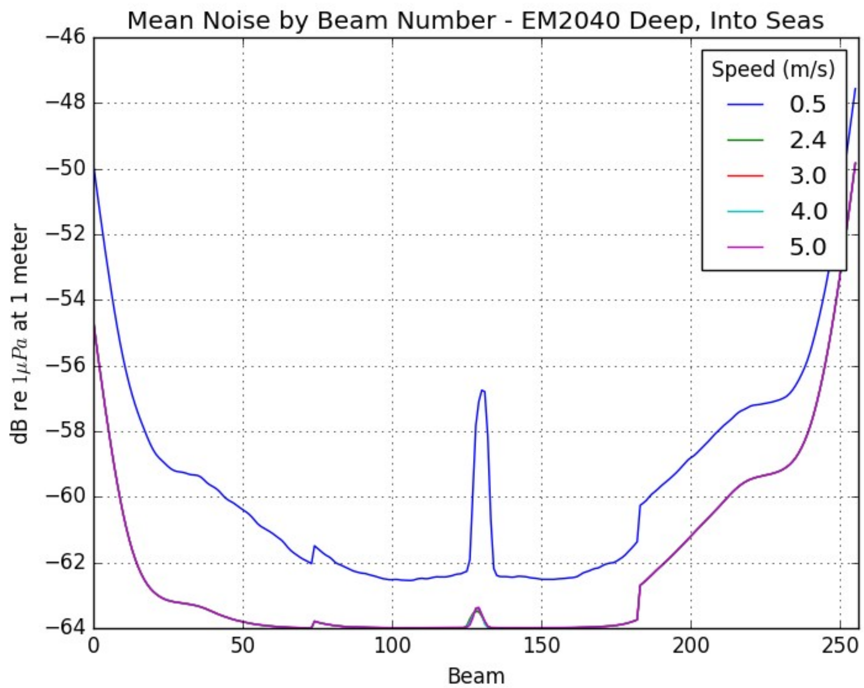


Figure 30 - EM2040 deep water passive water column noise averaged by beam and for each speed heading into the seas. EM2040 frequency setting was 200 kHz.

EM2040 deep water noise out of the seas is shown for comparison to the previous plots in Figure 31. The same data for not making way is used as for heading into the seas, thus the apparent difference between stopped and moving ahead in the previous plot is the same as between going into the seas and out of the seas, with heading down wind being a few dB higher.

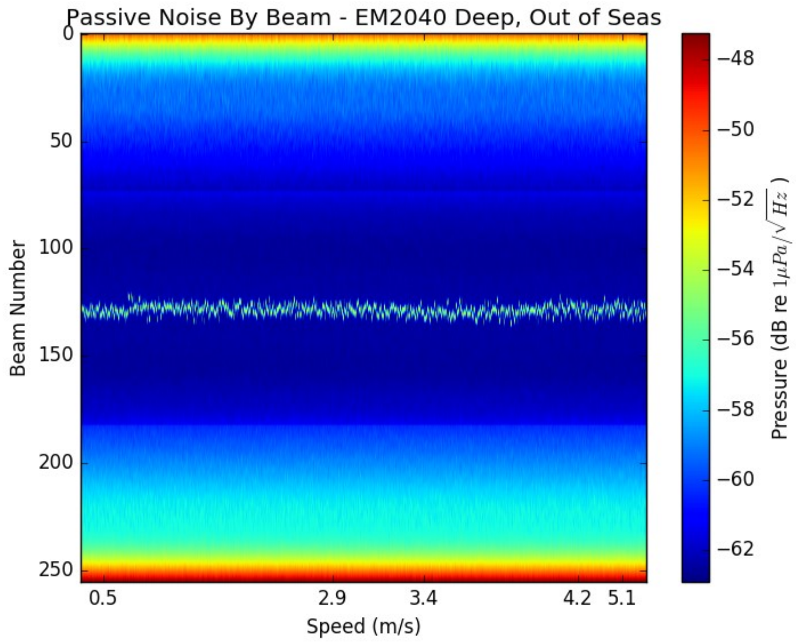


Figure 31 - Deep water passive water column noise averaged by beam heading out of the seas.

EM2040 shallow water BIST noise testing from 14 meters of water within Chesapeake Bay is presented in Figure 32. During the first set of tests the speed log was on and caused significant interference. At 500 RPM there is additional burst noise for the lower frequencies. Figure 33 shows how the EM2040 operates with low background noise across all frequencies with the same burst noise at 500 RPM. Again, the speed log was active during the first set of tests and was clearly interfering with all frequencies, although how it interfered depended on how the speed log transmit timed with the test.

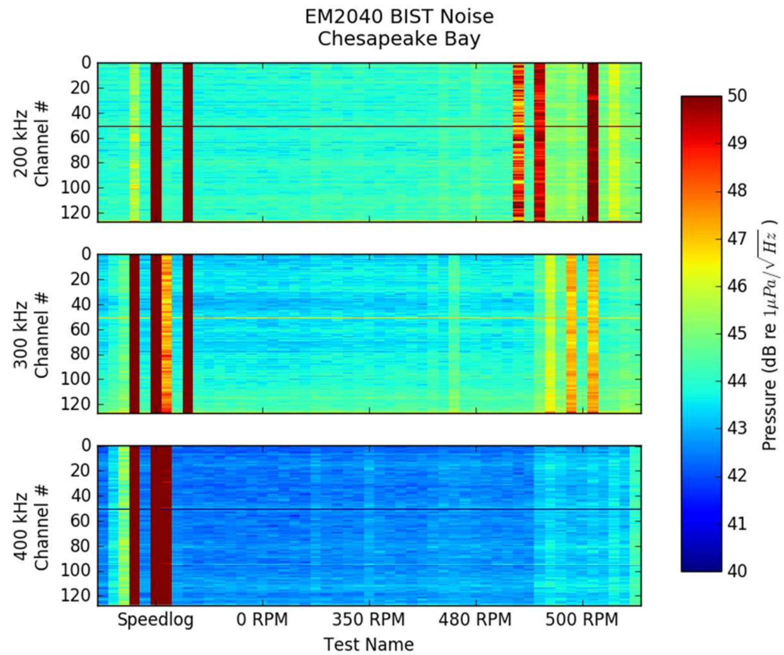


Figure 32 – EM2040 RX Noise BIST Tests from 14 meters of water in Chesapeake Bay. High, intermittent levels are interference from the Doppler speed log.

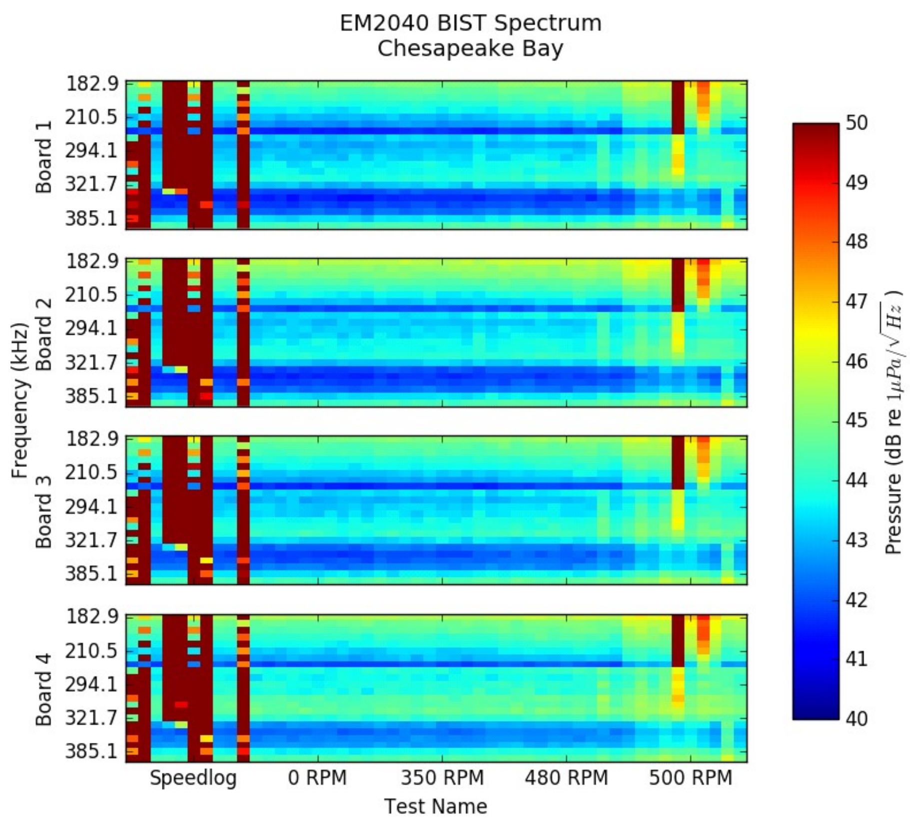


Figure 33 - EM2040 RX Noise Spectrum test from 14 meters of water in Chesapeake Bay. High, intermittent levels are interference from the Doppler speed log.

Passive water column showed consistent noise results across all frequencies for all speeds as show in Figure 34, Figure 35, and Figure 36. The speed log was secured for these tests. The nadir noise spike is most significant at 300 kHz, but also exists for all speeds for the other frequencies. A significant number of poor seafloor detections at nadir may result from this change in background noise in shallow water.

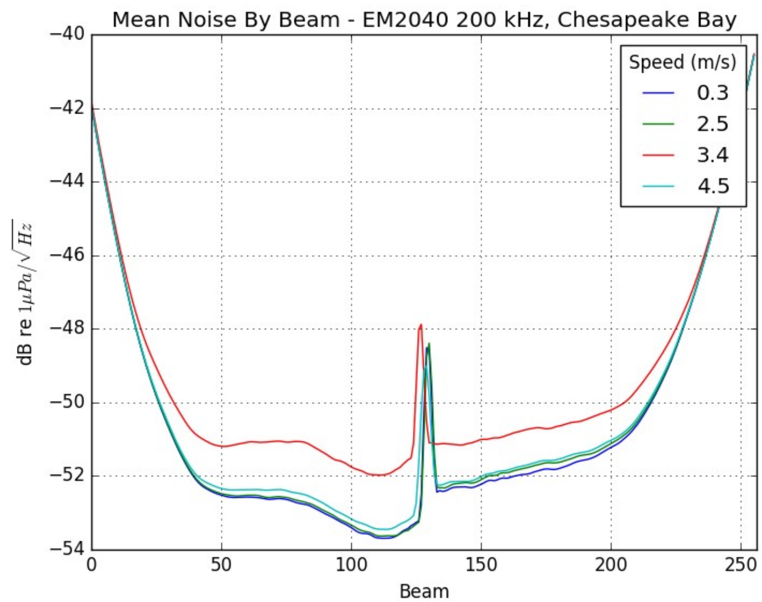


Figure 34 – EM2040 passive water column noise for the 200 kHz mode as averaged by beam and for each speed in 14 meters of water.

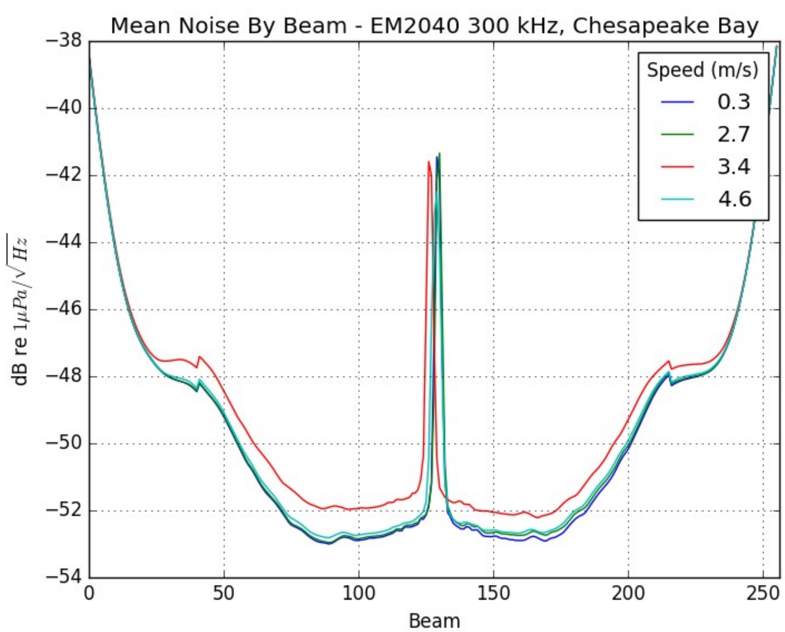


Figure 35 - EM2040 passive water column noise for the 300 kHz mode as averaged by beam and for each speed in 14 meters of water.

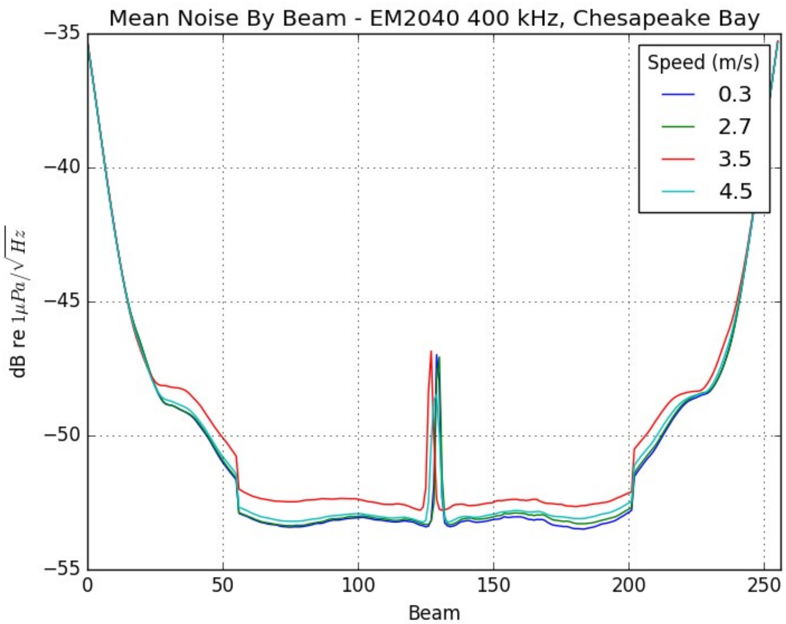


Figure 36 - EM2040 passive water column noise for the 400 kHz mode as averaged by beam and for each speed in 14 meters of water.

Figure 37 through Figure 40 are included to further stress the effects of the bridge speed log on the EM2040. The first two plots are for the 200 kHz mode, while the second two plots are for the 300 kHz mode. The beam averaged passive water column shows the change in average backscatter levels by ping. A single ping from each frequency setting is also shown to demonstrate the effect of the speed log in a real time view of the water column. The speed log should be secured during multibeam acquisition.

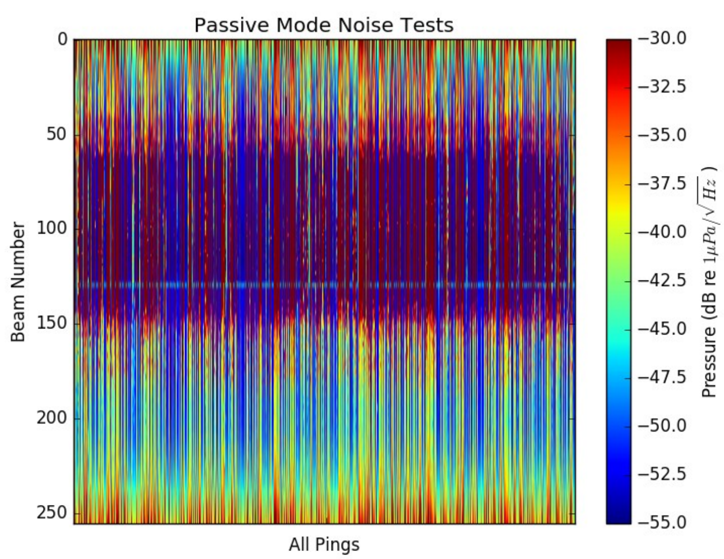


Figure 37 - EM2040 passive water column noise for the 200 kHz mode as averaged with each beam in 14 meters of water. The speed log was active during this test.

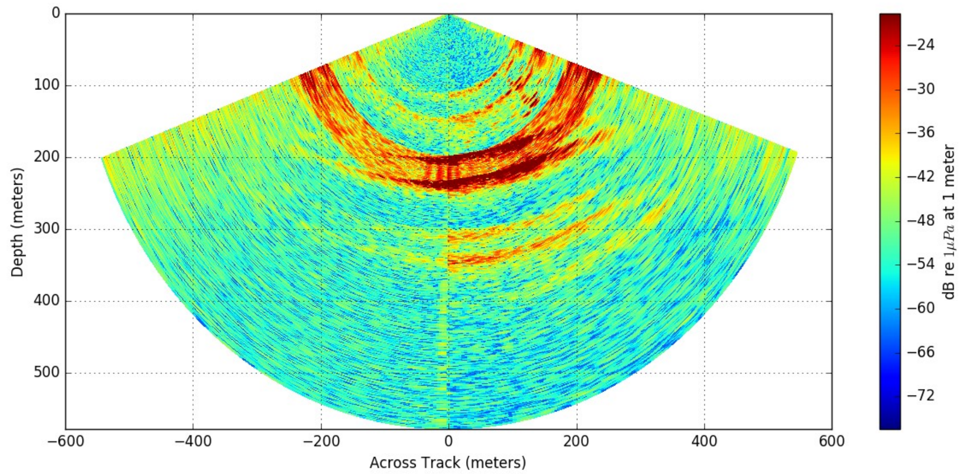


Figure 38 – EM2040 passive water column from a single “ping” for 200 kHz mode. Speed log interference is evident.

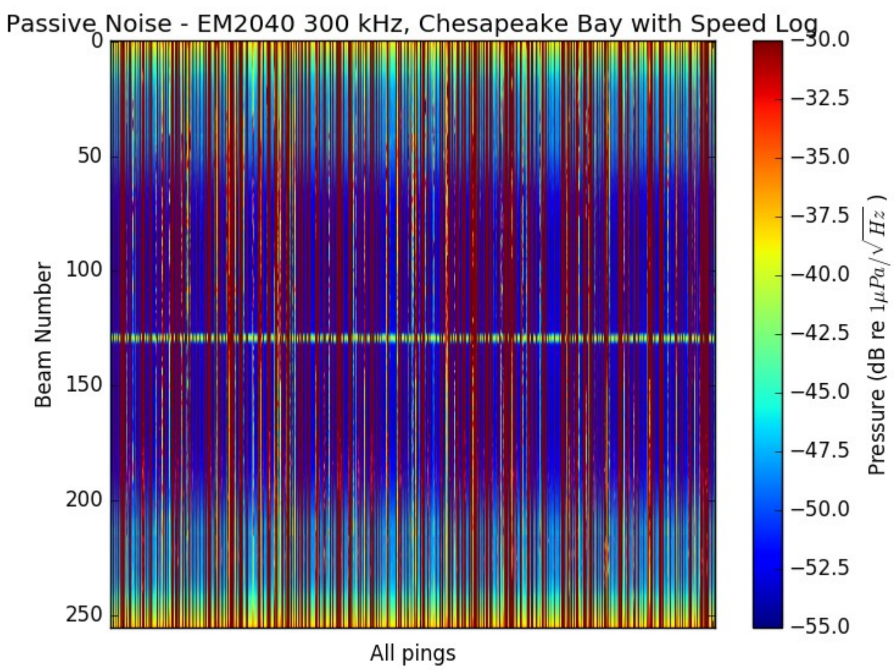


Figure 39 - EM2040 passive water column noise for the 300 kHz mode as averaged with each beam in 14 meters of water. The speed log was active during this test.

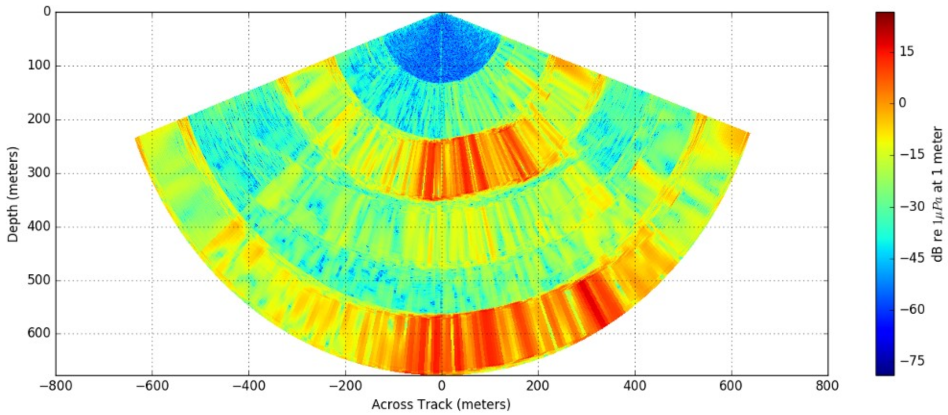


Figure 40 - EM2040 passive water column from a single "ping" for 300 kHz mode. Speed log interference is evident.

EM2040 noise testing was also conducted in approximately 70 meters of water as described previously. This dataset includes higher rates of speed than were collected in Chesapeake Bay and are thus presented here for completeness. No significant speed dependent change in noise is seen in the RX BIST Noise test as shown in Figure 41, although there does appear to be some additional burst noise at 10 knots. The RX BIST Spectrum Noise test also shows good background results across all speeds with the same burst noise at 10 knots. Background noise levels are higher in the Chesapeake data than for the deep water and 70 meter tests, indicating some effect from seafloor reverberation of vessel noise.

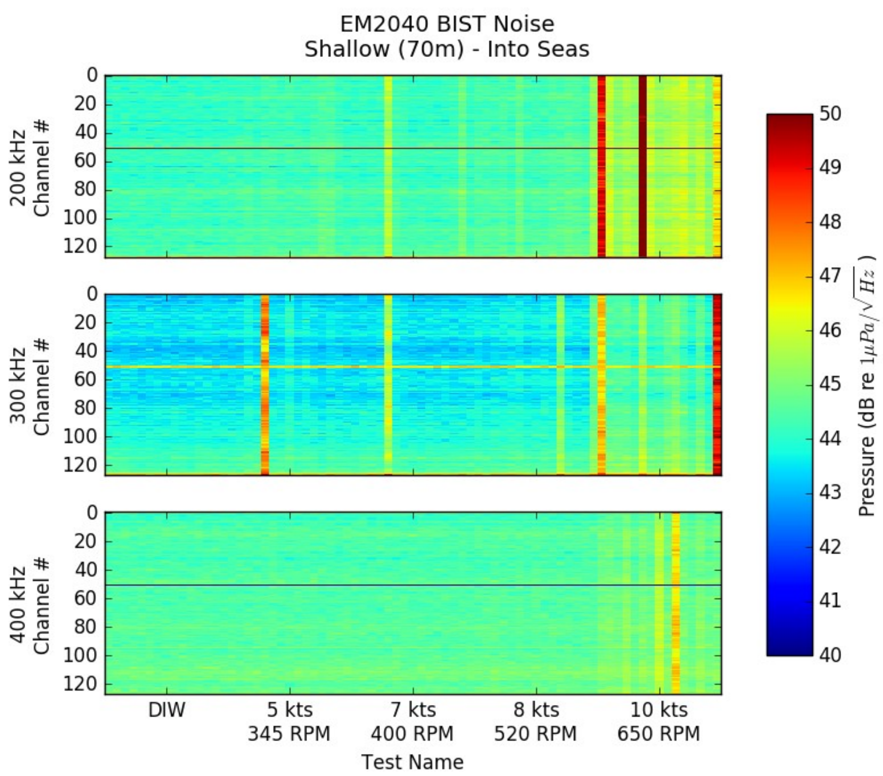


Figure 41 - EM2040 RX Noise BIST Tests from 70 meters of water and into seas.

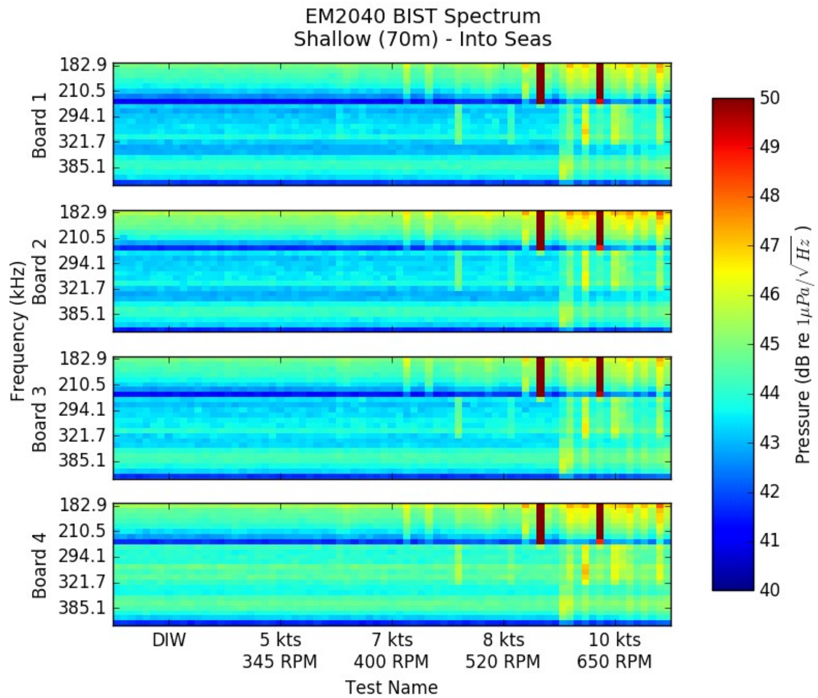


Figure 42 - EM2040 RX Noise Spectrum test from 70 meters of water and heading into seas.

For comparison to the Chesapeake Bay data, the passive water column data from the 70 meter areas is in Figure 43 and Figure 44. The background noise level is more on par with the deep water noise data, and the nadir noise spike is much lower for the slowest (DIW and 2.6 kts) and highest (5.6 kts) speeds.

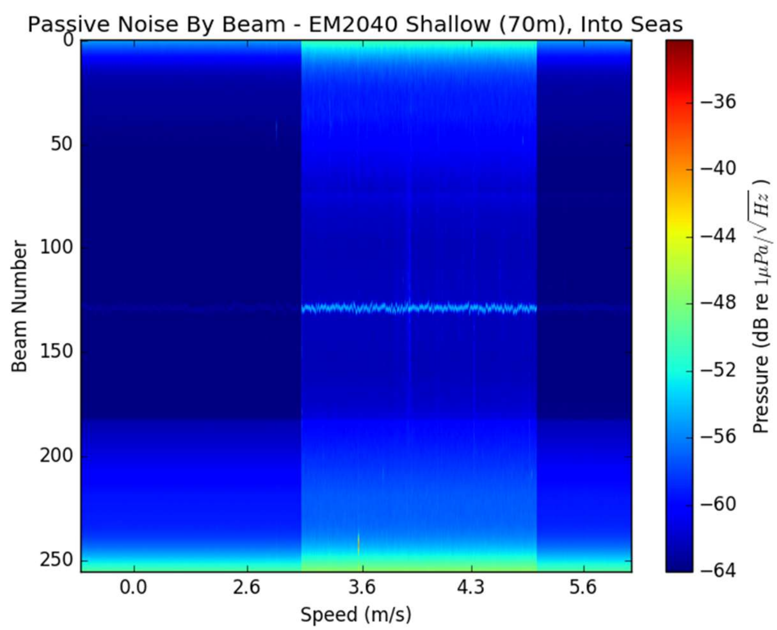


Figure 43 – EM2040 300 kHz passive water column averaged by beam, heading into seas in 70 meters of water.

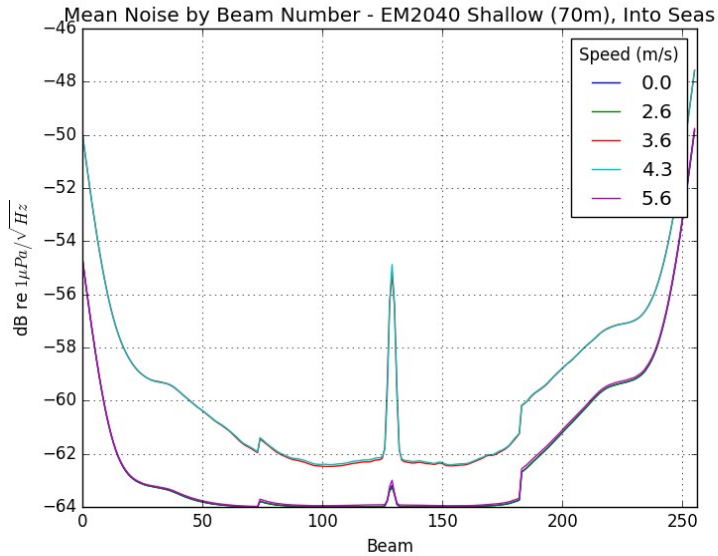


Figure 44 – EM2040 passive water column in 70 meters of water averaged by beam and by speed while heading is into seas.

These results do not indicate a specific recommended noise limited survey speed for the EM2040. Flow noise above the DIW level is not observable in either shallow or deep water. While the noise floor is higher in shallow water, it is not particularly dependent on speed and may or may not be due to the self-noise of the ship itself.

EM710 Noise Testing

Passive water column testing for the EM710 was conducted in Shallow mode and with a 500 meter range. These tests were conducted at the same location and time as the deep water EM2040 noise tests.

Deep water noise testing did not demonstrate any speed dependence in the BIST noise tests for levels by channel or by frequency other than small burst noise at the highest speed (Figure 45, Figure 46). Both into and out of seas had similar results.

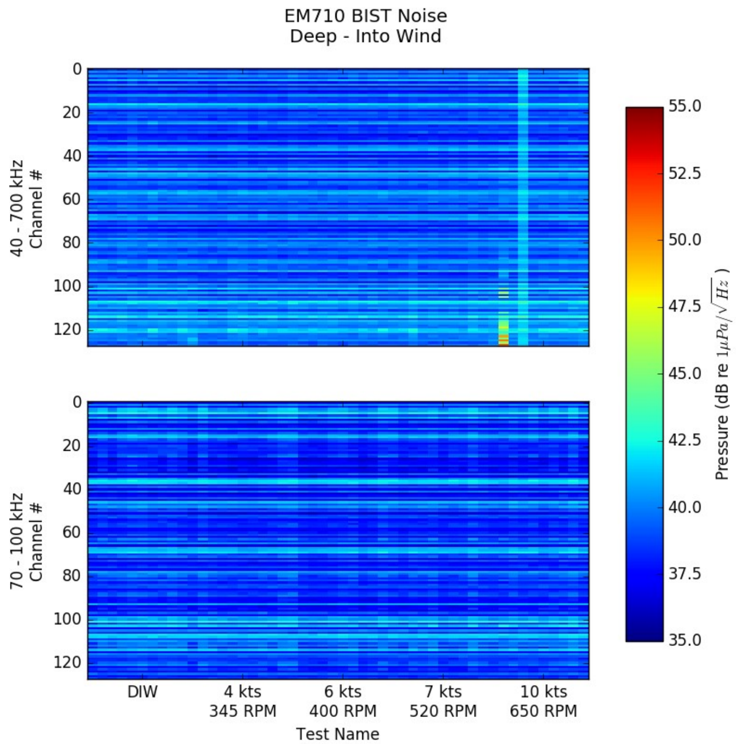


Figure 45 - EM710 RX BIST Noise by speed and heading into seas in 2500 meters of water.

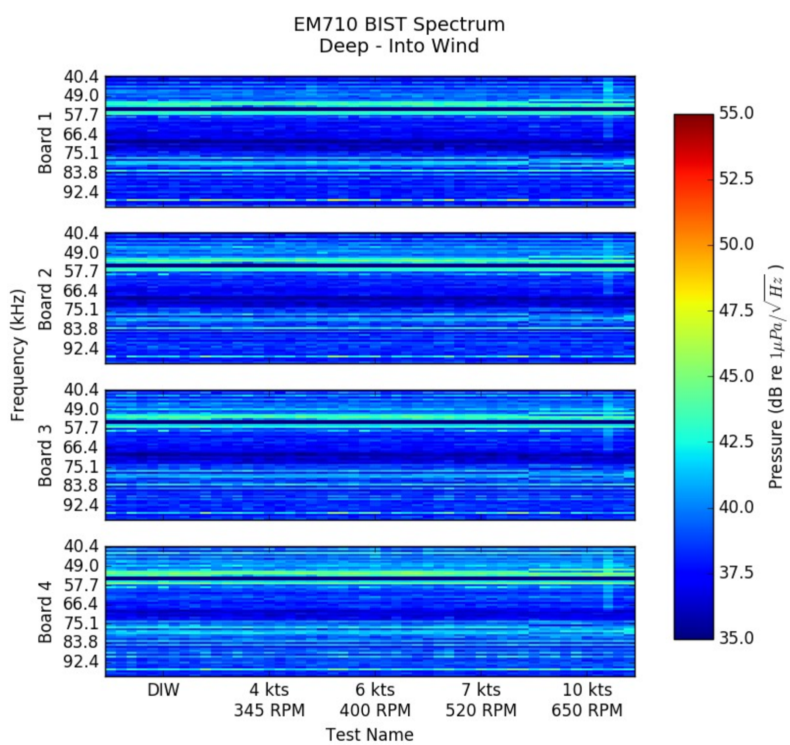


Figure 46 – EM710 RX BIST Noise Spectrum by speed and heading into seas in 2500 meters of water.

The beam formed passive water column showed more noise toward the outer swath at the highest speed, but the coherent noise at nadir remained at the same level (Figure *51*, Figure 52).

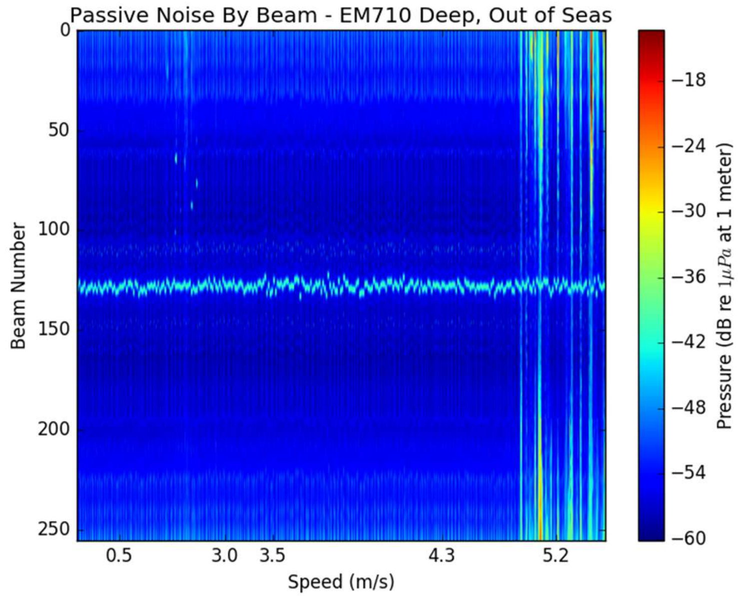


Figure 47 - EM710 passive water column averaged by beam, heading into seas in 2500 meters of water.

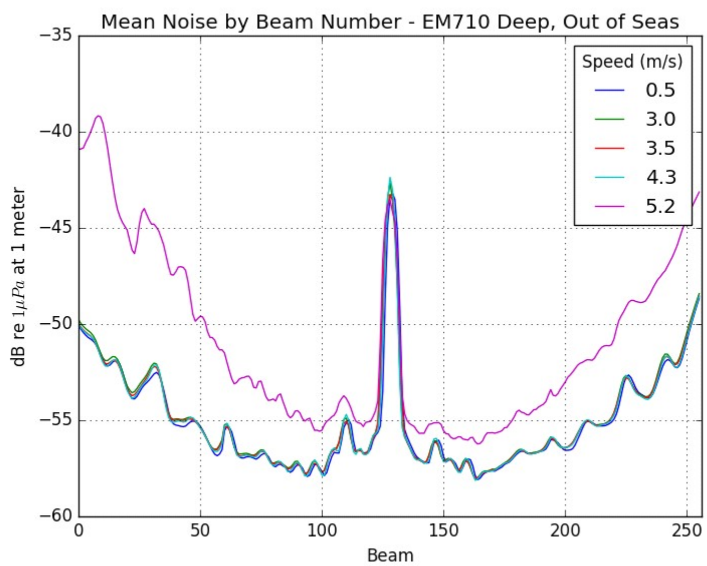


Figure 48 - EM710 passive water column averaged by beam and by speed, heading into the seas in 2500 meters of water.

Shallow water noise testing for the EM710 was conducted at the same location and time as the EM2040, and with the same settings as for the deep noise testing. BIST RX Noise and Noise Spectrum tests do show a speed dependence in this depth of water (70 meters), with higher background noise at higher speeds. Because this increase in levels was not observed in the deep area, this noise is likely not flow noise, but rather propulsion related self-noise propagating to the receiver via a bottom-bounce acoustic (e.g. downward radiated propeller noise, machinery noise through hull, etc.).

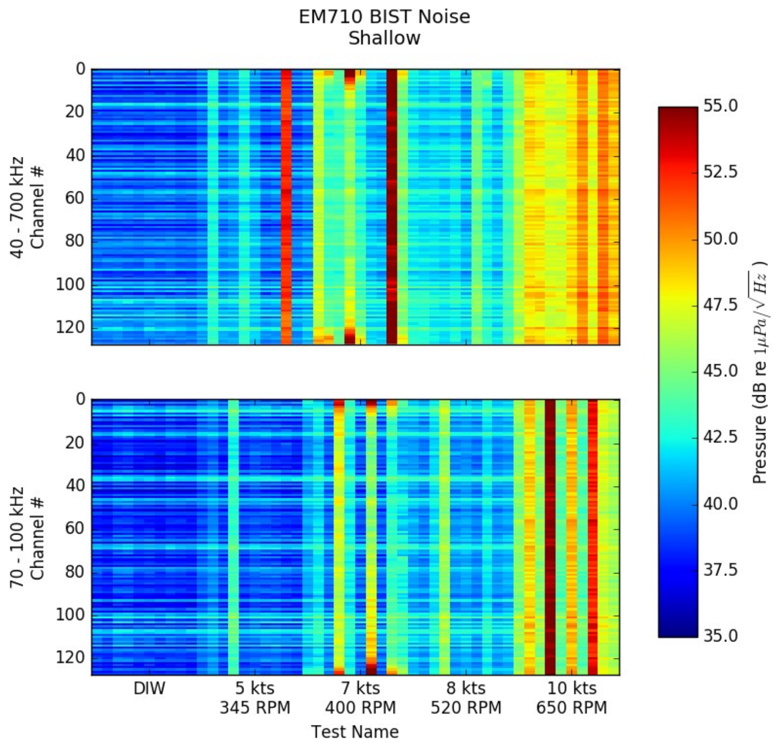


Figure 49 – EM710 RX BIST Noise by speed and heading into seas in 70 meters of water.

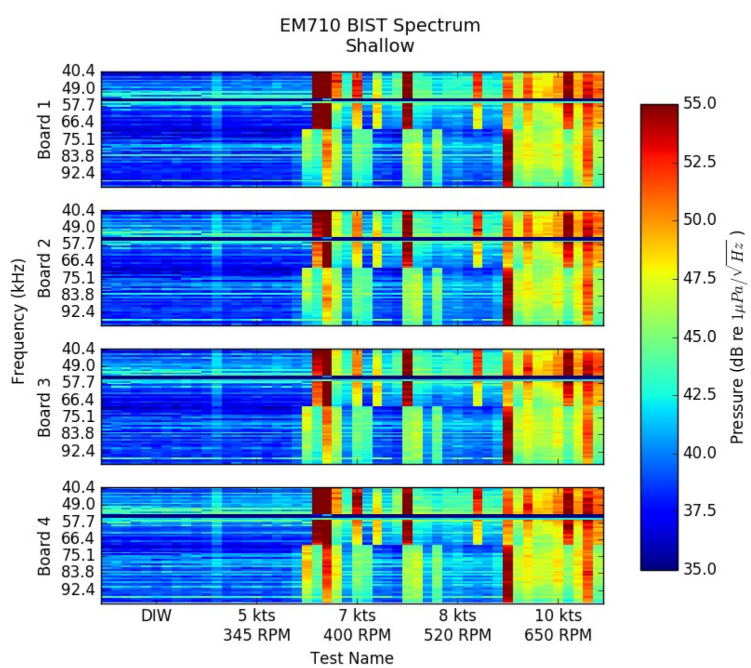


Figure 50 – EM710 RX BIST Noise Spectrum by speed and heading into seas in 70 meters of water.

Passive water column confirms the speed dependent noise observed in the BIST Noise tests in this water depth with the EM710. The change in background noise is most significant around nadir (as would be expected with an in-band bottom bounce noise source), which could potentially lead to noisier detections in this area of the swath at higher speeds and in shallow water. There is no clear noise floor limiting cutoff in acceptable survey speed.

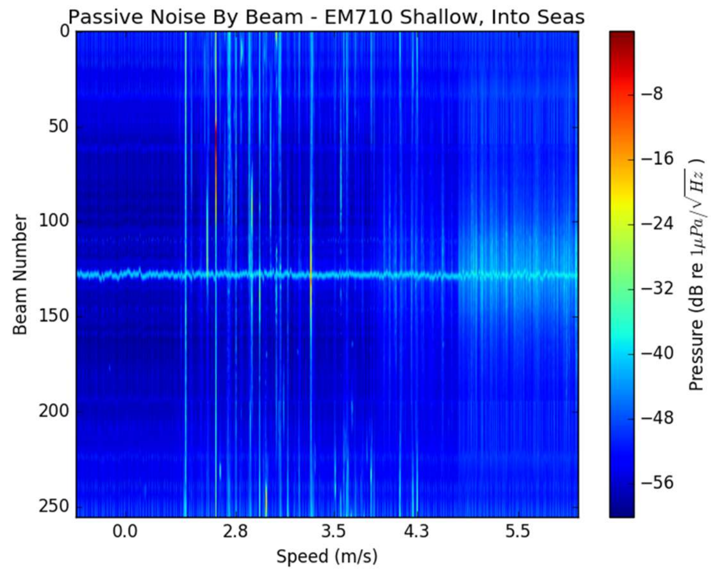


Figure *51* - EM710 passive water column averaged by beam, heading into seas in 70 meters of water.

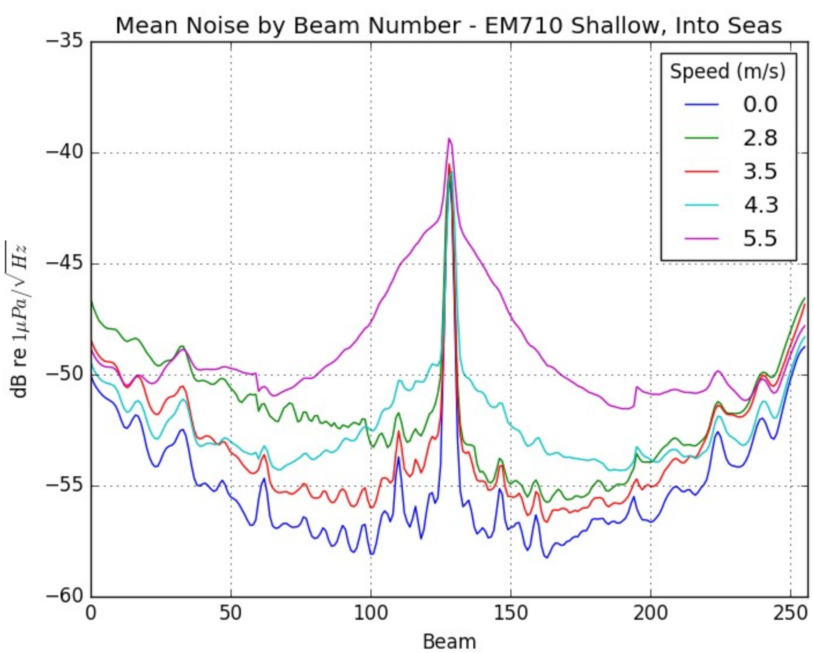


Figure 52 – EM710 passive water column averaged by beam and by speed, heading into the seas in 70 meters of water.

6.4 Target detection and recognition

Observations of objects

The Bow Mariner wreck site contains many objects that are useful for testing a system's ability to detect and recognize an object. Three objects were chosen to be investigated with both the EM2040 and EM710. A debris field 1100 meters north of the wreck has an object that appears to stand 2.5 meters proud of the surrounding seafloor, which is 76 meters deep. This object appears to be approximately 5 meters wide. In addition, the Bow Mariner has several masts that were used as objects for investigation. The bow mast appears to stand 14 meters above the deck, which is at 55 meters of depth, with an unknown width. The aft mast, just forward of the bridge, appears to stand 9 meters from the deck, which is 55 meters from the surface, and be 4 meters wide.

The object detection performance of each multibeam was evaluated by counting the number of detections both on top and in total on the object above the seafloor. While this counting method is somewhat subjective (i.e. identifying what sounding is on the "top" of an object, which in this case was simply within the observed cluster within approximately 0.2 meters of the average depth on top of the feature), the number of points that would change from one count type to another should not have a meaningful impact on the conclusion. Figure 53 shows the object north of the wreck and illustrates how the points were counted. The EM2040 was in 300 kHz mode and the EM710 was in Very Shallow mode. The EM2040 was tested twice for each angle, once with the "Normal" detection mode and once with the "Min Depth" detection mode mentioned previously. No manual cleaning of soundings was completed for this analysis, and while points that could be considered noise were tracked, they were few enough that they did not present any meaningful conclusion for survey operations.

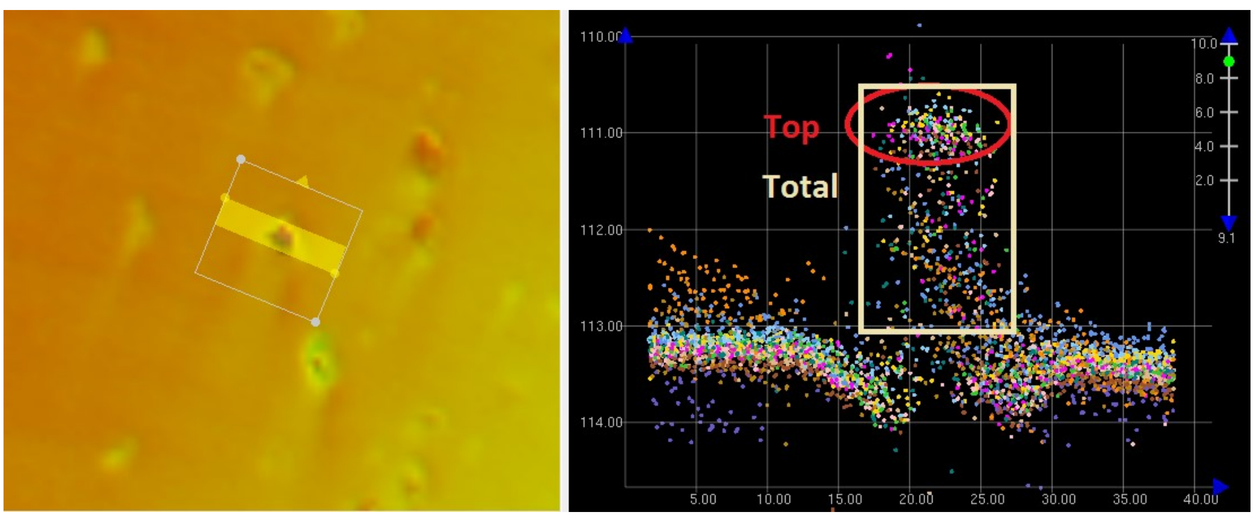


Figure 53 – The seafloor object 1100 meters north of the Bow Mariner wreck used for object detection work. Depths are in meters from the ellipsoid.

Lines were run at different offsets from the target to investigate the effect of across track angle on detections. The sounding counts for the EM2040 from swath angles between -20 and 71 degrees from nadir as shown in Figure 54.

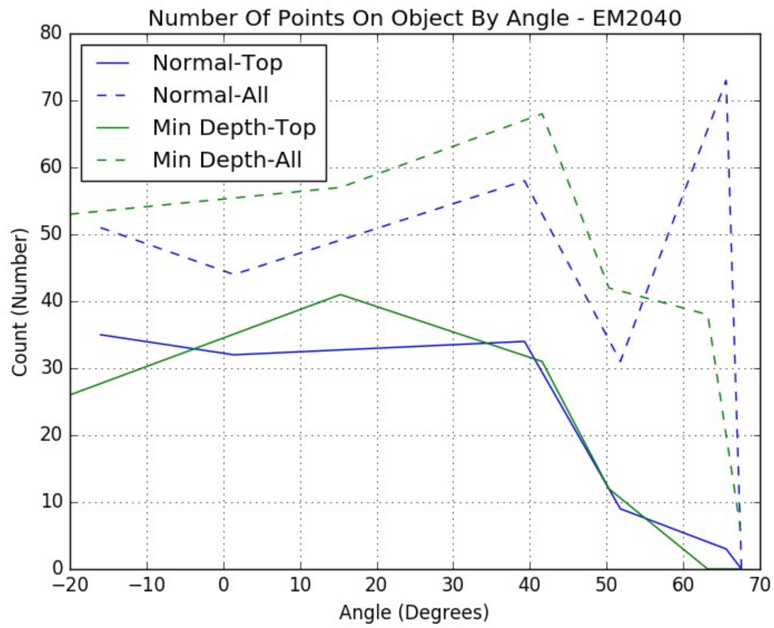


Figure 54 – The number of detections on the object by the EM2040 by angle and for the Normal detection mode and Min Depth detection mode. "Top" is the number of detection on the top of the object, while "All" is for all points perceived to be anywhere on the object.

The EM2040 appears to make more than half of its detections on the top of the seafloor object, making the representation of the least depth likely. Past 40 degrees, there are still numerous detection on the feature, thus making detection of the existence of a feature likely, but the number of detections on the top of the feature drops off quickly. Out to 65 degrees there are still detections on the object but the least depth is no longer reliably captured. The min-depth setting did not substantially increase the detections on the top of this object.

Using the same lines and methods, the sounding counts for the EM2040 from swath angles between -20 and 71 degrees from nadir as shown in Figure 55.

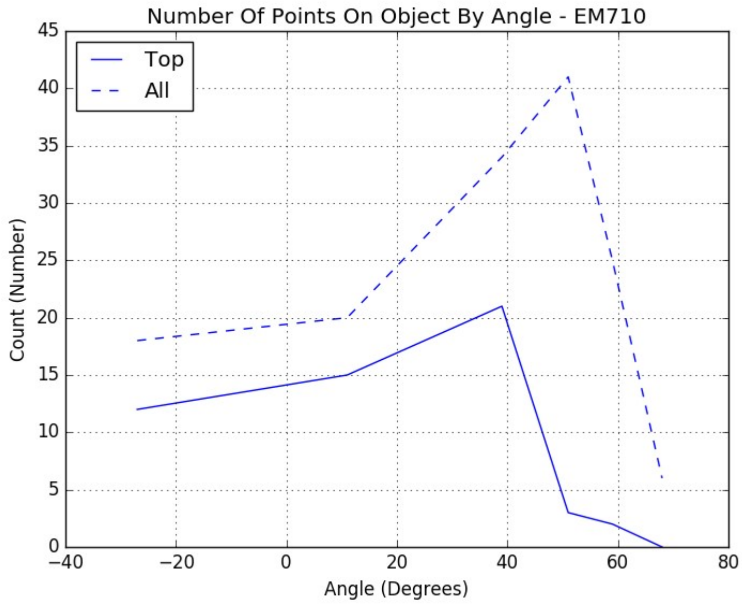


Figure 55 - The number of detections on the object by the EM710 and by angle. "Top" is the number of detection on the top of the object, while "All" is for all points on the object.

The EM710 does not have as many observations on the object, potentially in part due to a slightly smaller transmit beam width. Still, enough points are on the top of the object out to 40 degrees that the object will likely be recognized as its least depth if observed. Outside of 40 degrees the number of points on the top of the object drops off quickly, though the total soundings on the object are still high. Like the EM2040, detection of an object outside of 40 degrees is likely, but reliable detection of the least depth may not be.

The same analysis was completed for the bow mast on the Bow Mariner wreck (Figure 56). The number of these detections was not as consistent as for the seafloor object, so the results are presented in tabular form (Table 3).

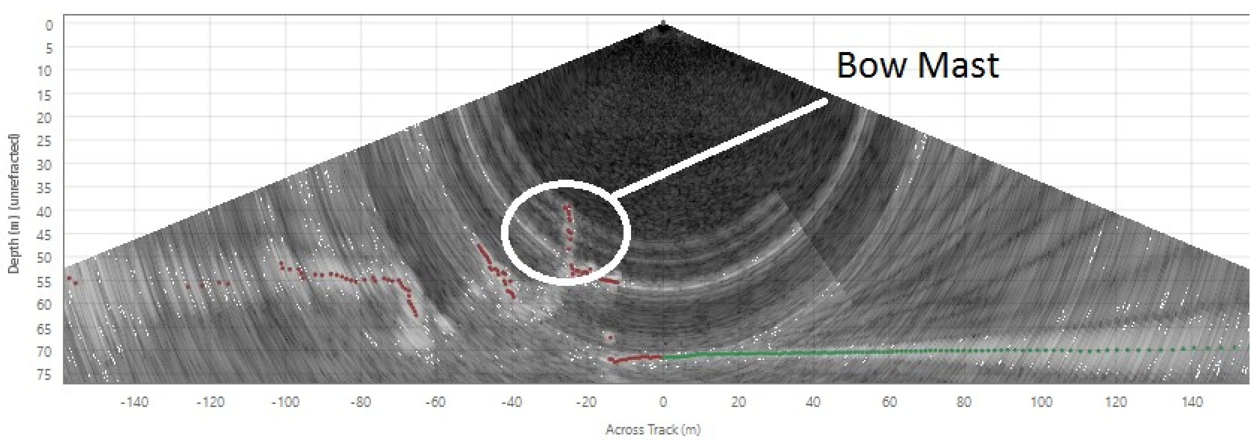


Figure 56 – The bow mast feature as observed with the EM2040.

Table 3 – The number of EM2040 observations on the forward mast for the top of the object and total on the object by angle.

Angle (Degrees)	-30	22	71
Top / Total, # of points, Normal Detection Mode	0/3	0/8	0/0
Top / Total, # of points, Min Depth Mode	3/25	2/16	0/18

While the EM2040 does detect the forward mast with soundings reported on the structure, out of seven passes for each detection mode this object was only observed on three lines. Also, detections are only provided by the EM2040 on the upper part of the mast when the system is in "Mid Depth" detection mode. Qualitatively speaking, the object would only have been recognized if the system was in Min Depth mode as the total number of detections and detections on the top of the structure made the structure appear real rather than just noise.

The EM710 did not detect the bow mast on any of the survey lines.

This analysis was repeated for an aft mast near the bridge superstructure (Figure 57).

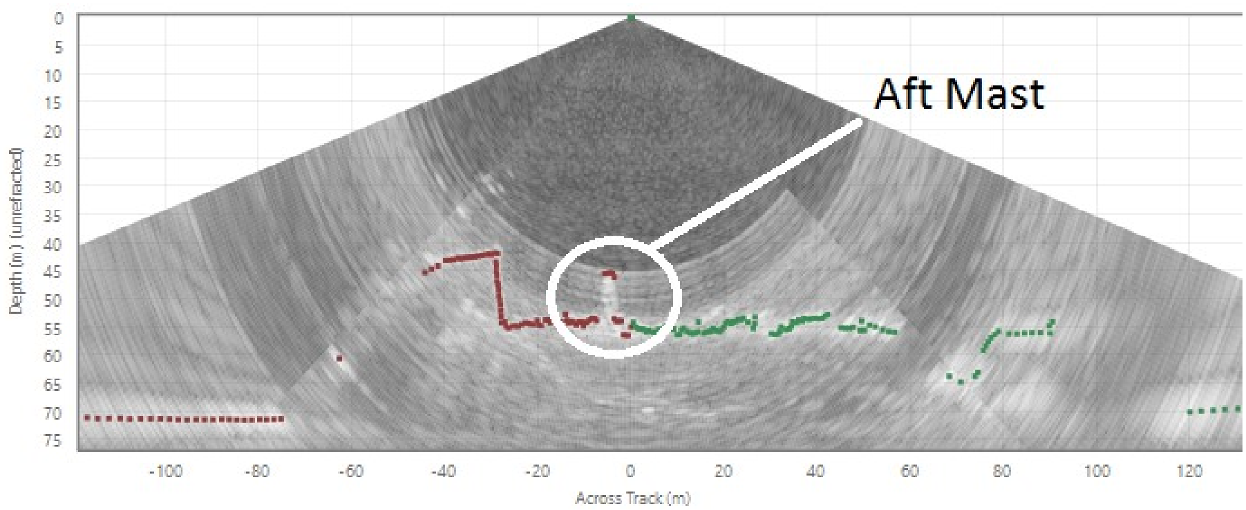


Figure 57 – The aft mast feature as observed in a single line with the EM2040.

Table 4 - The number of EM2040 observations on the aft mast for the top of the object and total on the object by angle.

Angle (Degrees)	-8	35	45	58
Top / Total, # of points, Normal Detection Mode	0/3	0/0	0/8	0/4
Top / Total, # of points, Min Depth Mode	9/11	0/5	0/5	0/0

While the EM2040 does detect the aft mast with sounding reported on the structure, out of eight passes for each detection mode this object was only observed on three lines for each mode. Detections are only provided by the EM2040 on the upper part of the mast when the system is in "Mid Depth" detection mode. While this structure appears to have more volume than the forward mast, from published pictures of the vessel it is also appears composed of a truss network rather than presenting as a solid target. Also, this mast is observed within the side lobe reverberation of the bridge super structure due to the heading during survey, making it difficult to have a clean detection. Qualitatively speaking, the object would only have been recognized if the system was in Min Depth mode as the total number of detections and detections on the top of the structure made the structure appear real rather than just noise.

The EM710 did detect the aft mast with 4 soundings, but these would not have made the object recognizable as a significant structure.

Observations from the two targets on the wreck suggest that it helpful to run the EM2040 in Min Depth mode when conducting developments over a structure with vertical structures typical of anthropogenic features such as wrecks. The Normal detection mode appears to function just as well as Min Depth mode over natural seabed objects. Min Depth mode did not appear to increase the amount of noise added to the dataset over Normal mode, either over the wreck or over the flat seafloor. Even so, Min Depth mode is likely to produce detections on water column objects, such as fish schools, which are not desirable for hydrographic surveys. Unless further compelling evidence is found, we recommend that Min Depth mode only be used during development work.

As noted previously, the number of noisy points around objects was also tracked. A screen grabs of the Bow Mariner is show in Figure 58 to illustrate the point. In general, there is very little noise.

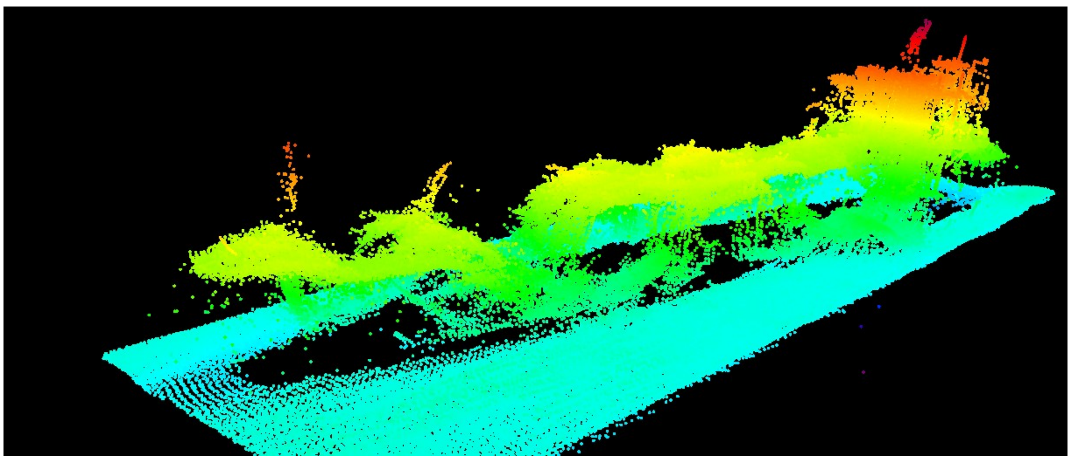


Figure 58 – EM2040 data from the wreck without cleaning.

It is worth pointing out, however, that when Kongsberg data is imported into Caris a significant number of rejected points may be included (Figure 59). Kongsberg systems will produce interpolated or extrapolated data but flag them as such. Caris imports this data and flags it as rejected by the echo sounder. It is important not to reaccept these points.

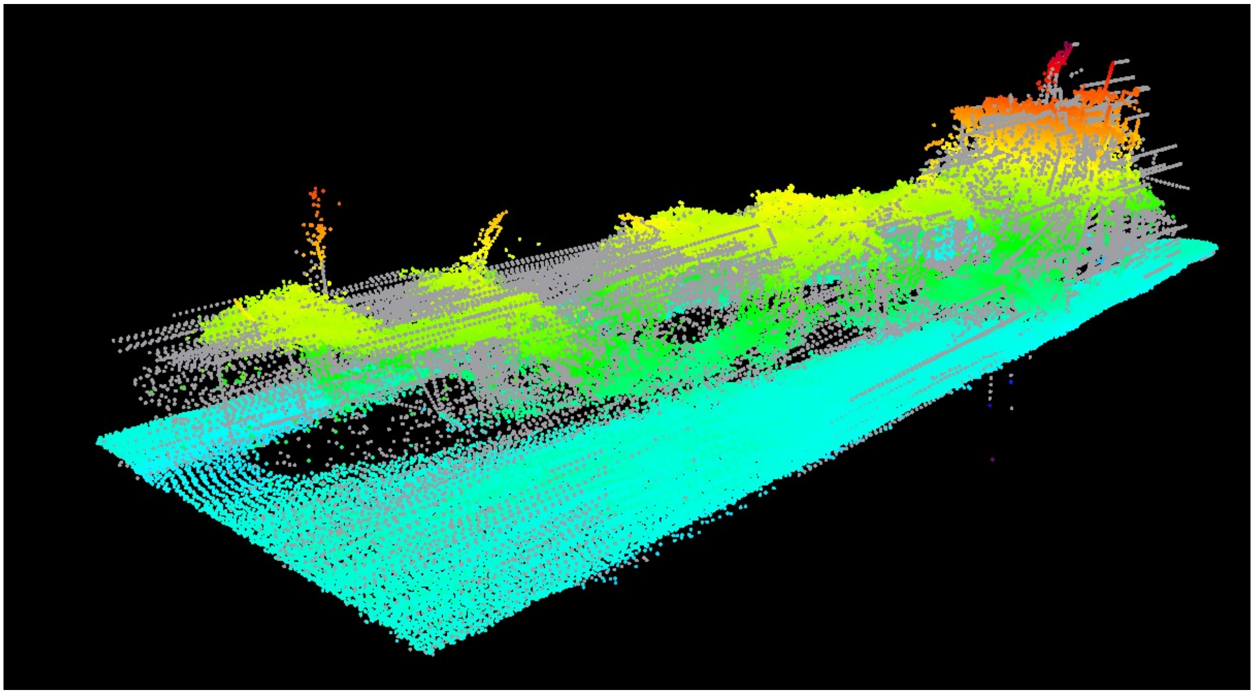


Figure 59 – EM2040 data from the wreck, showing data rejected, interpolated, or extrapolated by the MBES as grey.

Systematic Survey System Artifacts

During the acceptance cruise an outer beam bathymetric artifact was observed. This artifact was particularly noticeable over flat seafloors, and could not be correlated to motion. This artifact was also confounded by internal waves during targeted testing, further confusing its source. An example of the artifact can be found in Figure 60 and Figure 61.

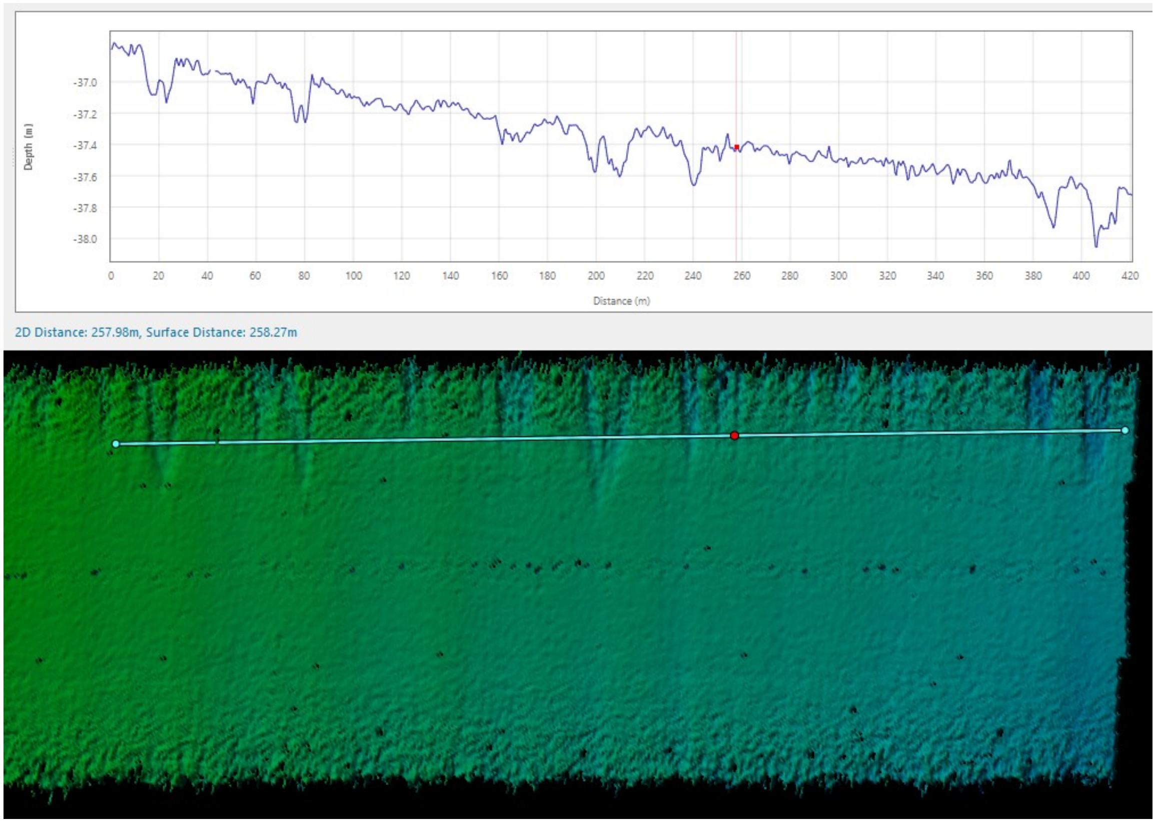


Figure 60 – The leeward artifact as observed in a single line of EM2040 data. The top plot is a profile view of the swath, while the bottom is an overhead view of the line along which the profile was taken. Heading was toward the left.

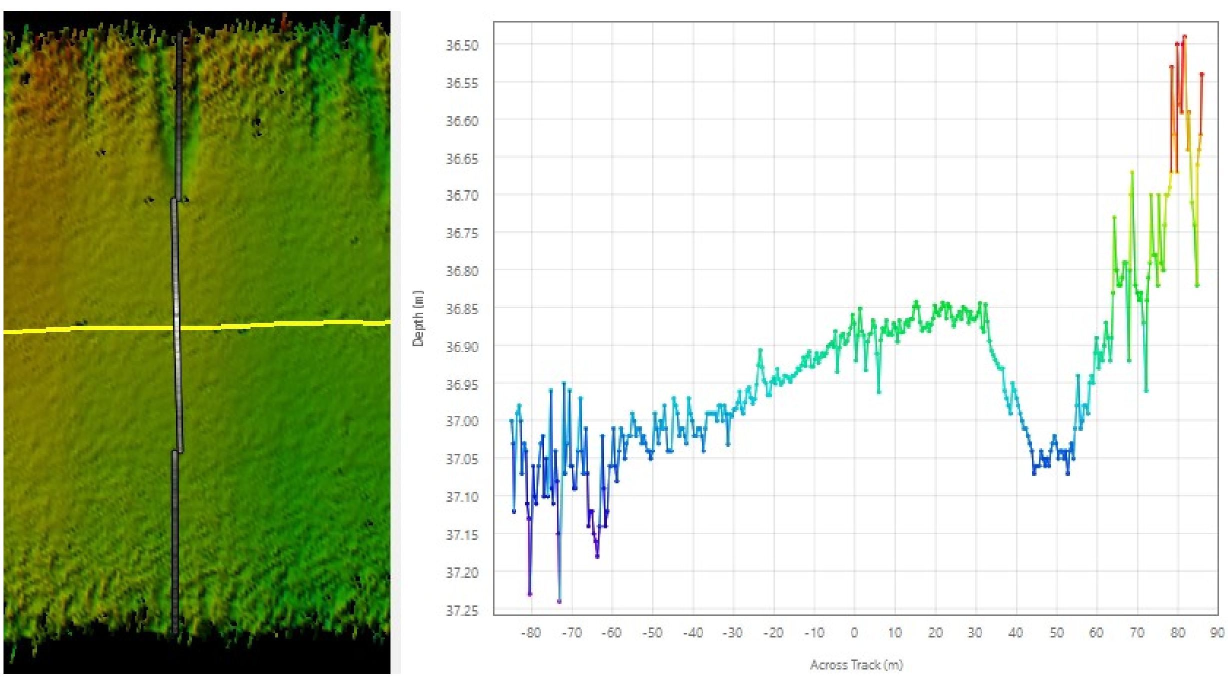


Figure 61 – The leeward artifact as observed in a single ping of EM2040 data. Left is the swath cross section, right is the single swath profile colored by depth.

This artifact occurs over multiple pings, apparently moving toward nadir and subsequently moving outward again. This artifact appears predominantly on the leeward side of the vessel, although can also exist on both sides when the weather is not abeam. After extended review by Kongberg and HSTB, and thanks to additional data collected by ship personnel post-acceptance cruise, this artifact is believed to be due to some upstream source of micro bubbles. The most likely sources of these bubbles could be one or more of three structures forward of the transducers, including a line cutter bar just forward of the transducer mount, a small appendage on the bow, or the bow thruster. The bubbles are not directly detected in the water column data or noise testing, but appear to be changing the sound speed of the water. Conceptually, as a cloud of microbubbles passes past the echo sounder, the beams are refracted away from nadir causing those beams affected to appear deeper. While this theory has yet to be proven, there is currently no other explanation that accounts for the relative weather direction dependence of this artifact.

Previous to the installation of the new survey echo sounders bubble sweep down was considered and discussed with field experts [5]. Because it was important to the U.S. Navy to conduct quality hydrographic surveys, previous testing of bubble sweep down of the *Thomas Jefferson* hull (as the USNS *LittleHales*) had been completed. Of the three likely sources of bubbles forward of the transducers, two were added since ownership of the vessel passed to NOAA, the cutter bar installed with the gondola, and the bow thruster. The cutter bar has been removed during a subsequent yard period, but no new testing for the artifact has been completed. If the artifact still persists, the bow thruster remains the likely candidate for the source of the bubbles since it was added by NOAA. Because abatement of bubbles with the bow thruster as the source will likely require significant modifications to the ship, plans for imaging the bubble cloud with cameras or imaging sonars has been discussed should the artifact still be present.

The standing recommendation is for the ship to collect EM2040 data in single sector mode until the bathymetric artifact is resolved. This restricts coverage to 45° on either side, reducing the likelihood that the artifact will be present in the collected bathymetry. While this configuration is not ideal, and a frustrating situation for a brand new survey system, the ship regularly conducts side scan surveys where the multibeam is primarily used to fill in at nadir and gather general bathymetry. In the short term limiting the data to only the good part of the swath will help avoid introducing questionable data into the survey workflow. This problem clearly needs to be resolved such that Coast Survey can use these new tools to their full potential.

6.5 Sonar Performance Parameters

The useable swath width as a function of depth is important to survey planning, survey quality, and survey efficiency. Both the EM2040 and EM710 were tested by running the systems up and down a slope and plotting the usable swath as a function of depth. The usable swath width is defined by the outermost good beam on each side of the swath as reported by the multibeam. Because seafloor type has a strong impact on the returned signal level, the achievable swath width does depend on the seafloor type. Ideally, we would run these tests over a steady slope of homogeneous (and known) sediment type. It is worth noting, that the identified outermost good beam can still contain noise or an incorrect depth as it has only been designated “good” by the system.

EM2040 Extinction Test

The EM2040 was tested for all frequency modes but left to automatically select the pulse length. The planned location for EM2040 extinction testing contained significant amounts of fishing gear, thus a different testing location was selected on the fly. While the improvised location for extinction testing had a suitable maximum depth, the minimum depth did not allow for all modes to clearly demonstrate how the system would perform in shallow water without considerable additional transit time. Also, this location appeared to have a significant change in the seafloor type (Figure 62) which caused an abnormal inflection in the extinction curve at approximately 200 meters (Figure 63).

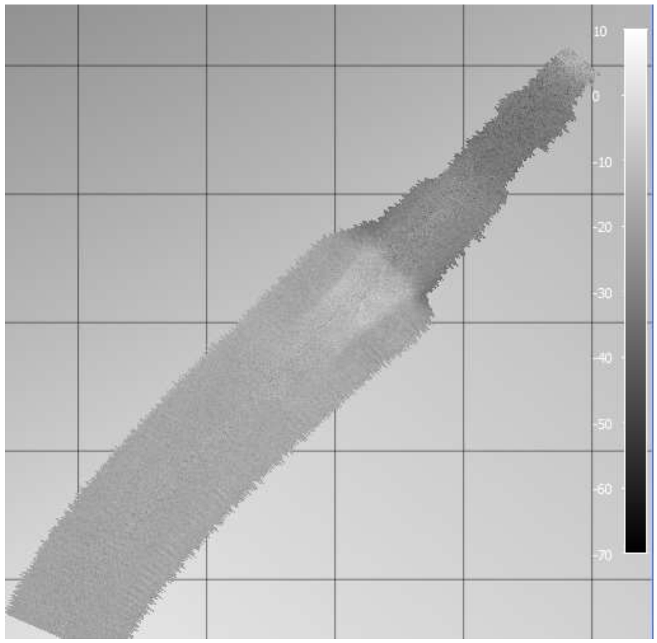


Figure 62 - A line in 300 kHz mode from the first extinction site demonstrating the change in backscatter as seen in QPS FMGT.

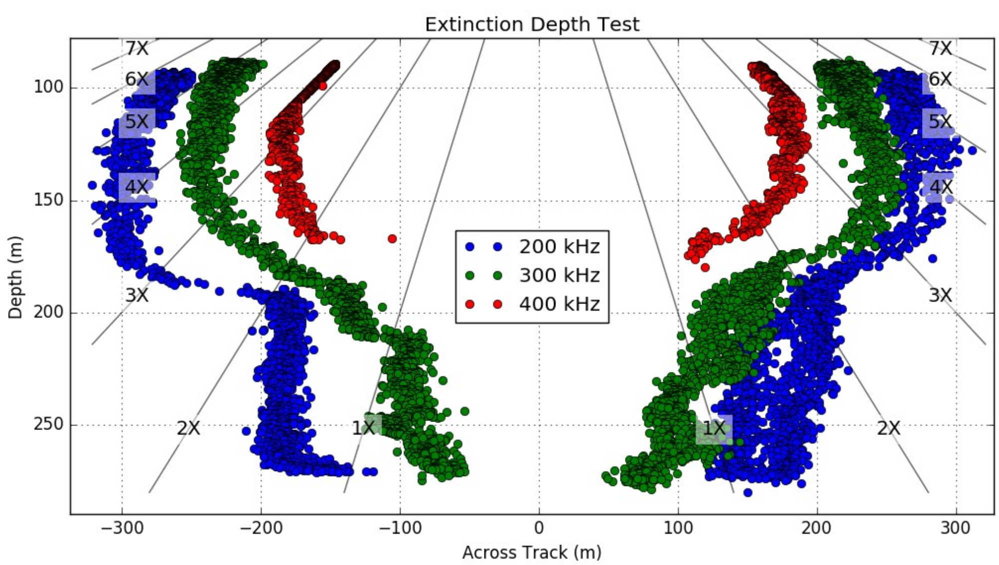


Figure 63 – EM2040 extinction data at the improvised location. The pulse length was selected by the system automatically. Shown are the outermost good detections on each side of the swath.

To supplement this test, the EM2040 was also run during the EM710 extinction test. 200 kHz data was collected while steaming down the slope, and 300 kHz data was collected while steaming up the slope (Figure 64). These results have a smoother transition between depths than the improvised location as would be expected for a consistent seafloor type over the test area.

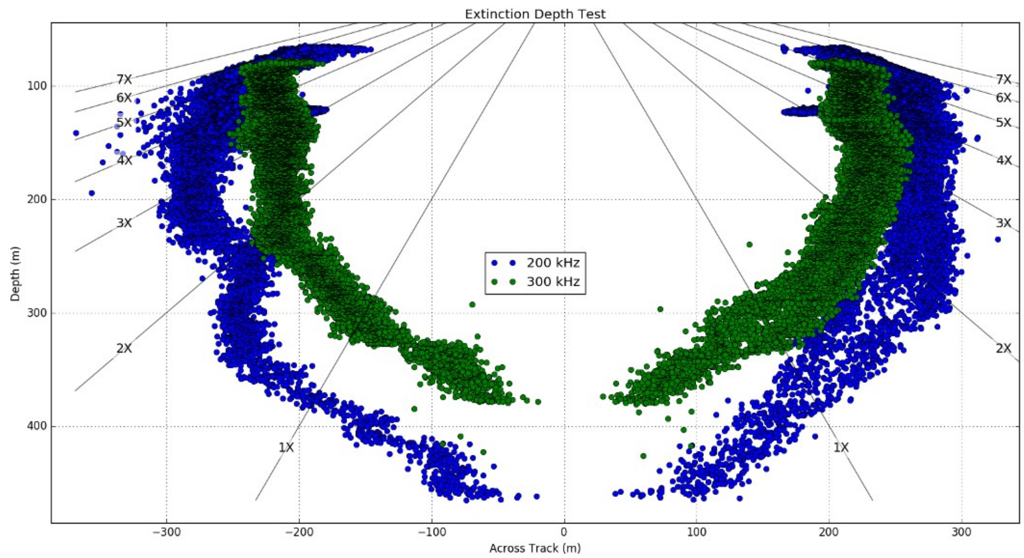


Figure 64 – EM2040 extinction testing on the EM710 extinction test line. The pulse length was selected by the system automatically. Shown are the outermost good detections on each side of the swath.

For all three frequency modes the *Thomas Jefferson* EM2040 appears to meet the Kongsberg specified swath width by depth within the uncertainty of variability due to seafloor type. In general, the performance follows the predicted extinction curve for a cold ocean with a sandy seafloor. The variability of the results with apparent seafloor type is expected, and worth remembering when planning surveys using these plots. Results will vary based on the seafloor conditions encountered in a particular area.

EM710 MKII Extinction Test

The EM710 extinction line ran from 75 meters down to 2500 meters of depth along the southern side of Hudson Canyon. This appears to be a good location for this test as the slope has minimal interruptions from canyons between the applicable depths that would interfere with the results. The EM710 was left to select the mode automatically, and was only tested in the 40 – 100 kHz mode. The other modes (e.g. 40 kHz mode, 50 kHz mode, and 70-100 kHz mode) largely use sub-modes of the 40 – 100 kHz modes, and *Thomas Jefferson* is expected to have no need to operate in these specific modes.

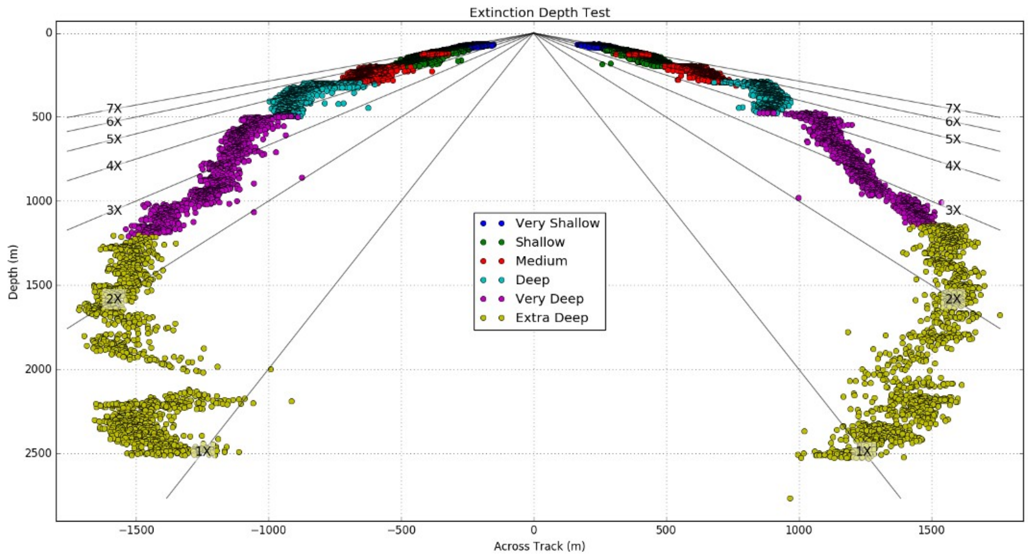


Figure 65 – EM710 extinction test results. The mode setting was selected automatically. Shown are the outermost good detections on each side of the swath.

The EM710 MKII follows the predicted seafloor performance predicted for a cold ocean with a rocky seafloor. While no seafloor samples were taken during acceptance testing, it is unlikely that the seafloor was rocky during the duration of the line. Assuming the seafloor was not rocky, the EM710 likely exceeds the predicted Kongsberg performance swath width by depth performance.

6.6 Backscatter quality assessment

Kongsberg multibeam echo sounders adjust the recorded seafloor backscatter to account for beam pattern effects. The real time backscatter can be improved and made more useful by updating this adjustment with values post-installation. To accomplish this, some form of backscatter calibration needs to be completed to update these parameters. Currently these parameters can be adjusted on the EM710 but not on the EM2040. The BSCorr.txt file stored on the TRU contains the power level used for each sector of each mode as well as the relative receiver sensitivity by angle. Previous methods adjusted the sensitivity settings to account for the differences in backscatter levels between sectors and modes. For *Thomas Jefferson* only the power levels were adjusted to align the sectors.

Two types of backscatter calibrations were used during this cruise for the EM710 modes mostly likely to be used aboard *Thomas Jefferson*. Time was not taken to calibrate the lesser modes less likely to be used (e.g. 40 kHz, 50 kHz , 70 – 100 kHz) since the available time for calibration was not clear when in the proper locations. The same method for collecting calibration data as was used in the past, consisting of a single line in each direction for each mode over a flat seafloor, was used in this case as well. Because of limited time for analysis, implementation, and testing, only the power offset was used to normalize between sectors. This approach improved the real time backscatter considerably (Figure 66) while also simplifying the changes needed to the Kongsberg BSCorr file. Modifying the angle sensitivities can be laborious if undertaken by angle as has been done previously.

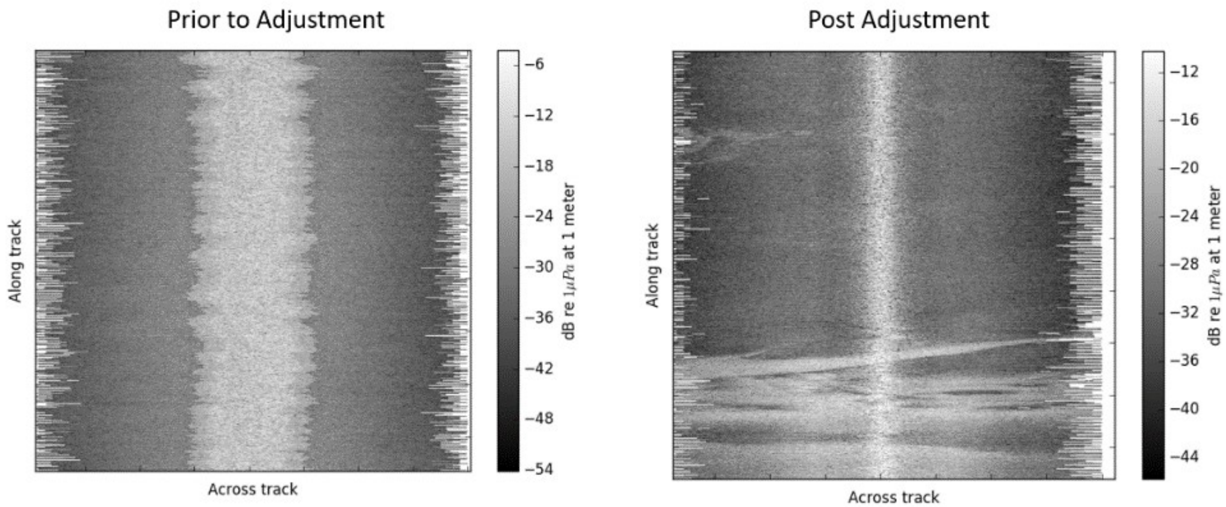


Figure 66 – Seafloor backscatter with the EM710 before the BSCorr.txt file was adjusted (left) and after adjustment (right).

The relative changes made to the port and starboard sectors to match the backscatter produced by the center sector are listed by mode in the summary in Table 5. The center sector was left with the default power value. The units for the sector power are not defined but are assumed to be some form of transmit power in dB.

Table 5 – The updates made to the default EM710 BSCorr sector power.

	Port Adjustment (KM Units)	Starboard Adjustment (KM Units)
Very Shallow – Dual Swath 1	+8.0	+8.0
Very Shallow – Dual Swath 2	+8.0	+8.0
Shallow – Dual Swath 1	+7.5	+8.0
Shallow – Dual Swath 2	+9.5	+9.5
Medium – Dual Swath 1	+6.0	+7.0
Medium – Dual Swath 2	+7.0	+8.0

Data were also collected for a secondary approach which was developed Dr. Anand Hiroji. These lines were run to determine the full transmit beam pattern as described in [6]. Dr. Hiroji continuous work on these data and will provided results to the ship when complete.

While the EM2040 backscatter was not calibrated, observation of the backscatter showed an unexplained artifact when operating in 200 kHz mode (Figure 67). This artifact appears as an area of depressed backscatter on the port side at 30 degrees from nadir, roughly where sector boundaries would be expected if 200 kHz had three sectors. The 200 kHz mode only has two sectors.

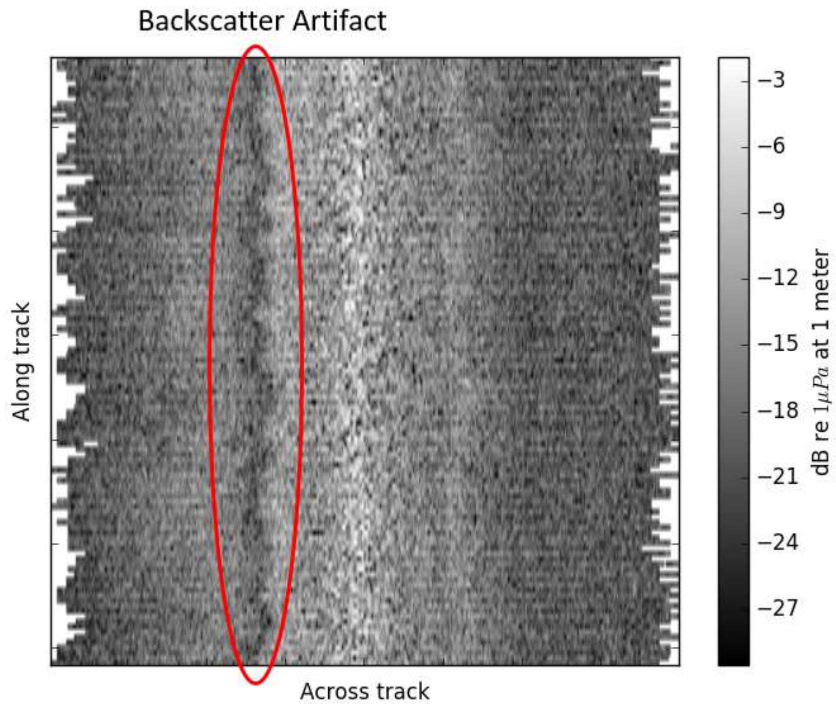


Figure 67 – The EM2040 200 kHz mode backscatter artifact.

Kongsberg identified changes to the installation that may remove or improve this artifact. Kongsberg was primarily concerned that the EM2040 transmitter was not protruding down from the cover plate sufficiently, and that the faring compound around the transducer may be interfering with transmission. In addition, they also recommended changing the amount of paint coating the transducers. They considered the amount of paint evident on the transducers from pictures excessive, and felt that it could also be impeding performance. These recommended adjustments were accomplished during a follow on shipyard period but testing to quantify any improvement has not yet been completed.

7 Data Workflow Integration

7.1 Test application of post processed correctors

Post processing for the *Thomas Jefferson* acceptance cruise was conducted in Caris HIPS versions 9.1 and Qimera 1.3. With previous Kongsberg installations in the NOAA fleet ([1], [2] ,[7]), the reference point was set as the transmitter of the echo sounder, and the output of the inertial navigation system was valid at this point. This configuration was chosen in those cases to eliminate the lever arm calculations in Caris, which had a known deficiency in applying delayed heave corrections for Kongsberg systems. For the *Thomas Jefferson*, we elected to make the IMU the reference point (see section 4.1.1 for more information). This choice was primarily motivated by the fact that with *two* multibeam systems and a single positioning system we could not have the reference point uniquely at *each* transmitter. This configuration is also common NOAA practice (for non-Kongsberg systems) and seems to be more intuitive to many. As tested in [3], the former lever arm related delayed heave errors seem to have been resolved in Caris 9.1, however survey work following the cruise in shallow water with extreme pitch revealed a residual pitch-related error and pointed to a complication with the desired HIPS workflow. A discussion of the current HIPS logic for Kongsberg systems as well as how the current version of SIS effects the workflow is provided here for clarity.

Kongsberg systems provide the end user with both a processed sounding solution and the angle-range raw data. Because the processed solution requires the application of many adjustments to the real time data, some of the data, such as the motion data, can be modified from its raw state. Most notable to this discussion, the motion data is modified according to the lever arms and angles provided in the Installation and Test Parameters Sensor Setup tab (Figure 68). Roll, pitch and heading have the values applied from the Attitude fields (commonly the patch test values), and heave is modified to account for the induced heave due the lever arms from the motion sensor to the transducers when the vessel is pitching (Figure 69). Thus the logged real-time attitude data in the .all file is valid at the transmitter and in the transmitter frame.   Because the real time solution is provided as vessel (reference point) relative x, y, and z sounding locations, the navigation data is not translated.

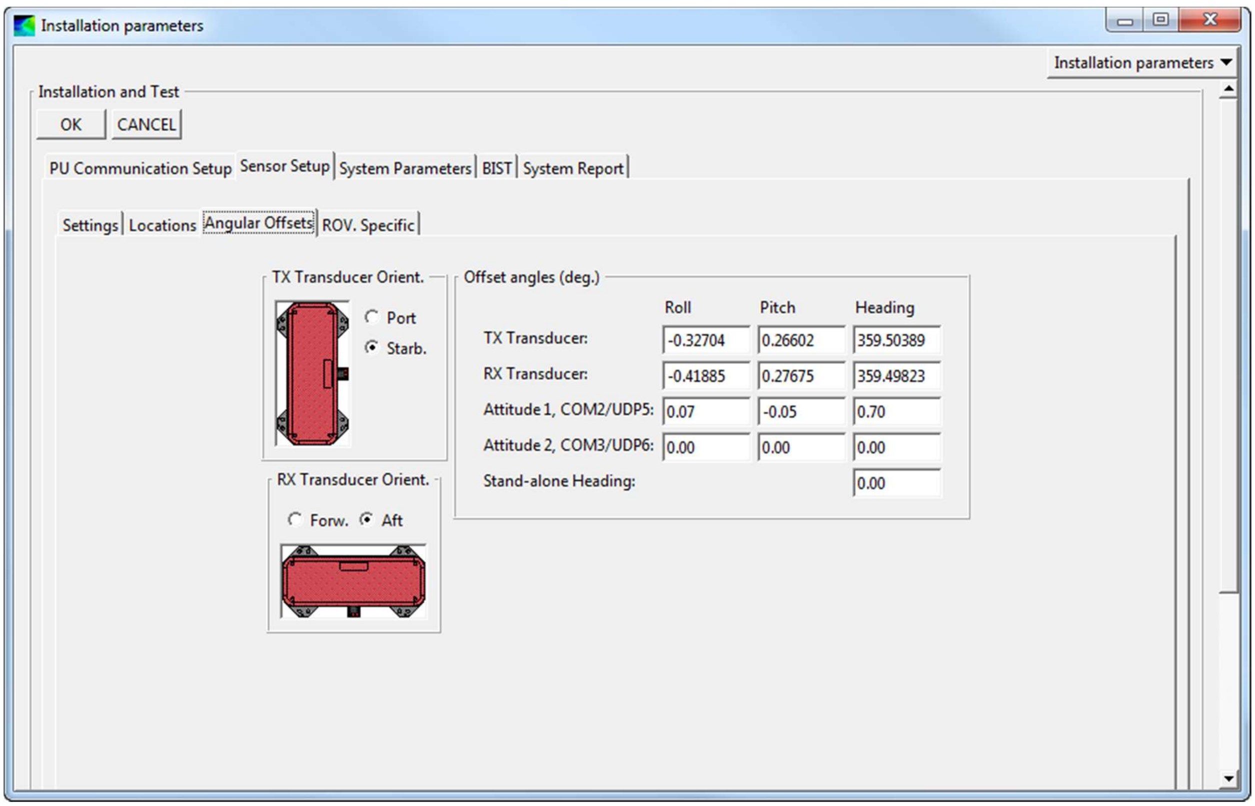


Figure 68 - The Installation and Test Parameters, Sensor Setup, Angular Offsets for the NOAA Ship Thomas Jefferson EM2040.

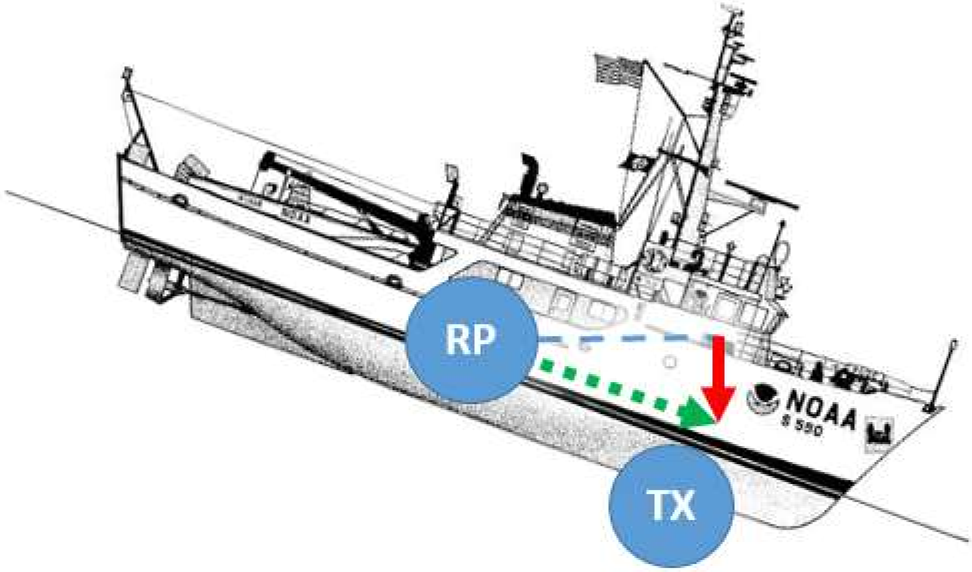


Figure 69 - Pitched induced heave (red arrow) is a result of the along track lever arm between the reference point (RP) and transducers (TX).

In summary: the SIS logged real-time attitude (including heave) is valid at the transmitter and in the transmitter frame; real-time navigation, including GNSS height information (e.g. GGK and EM Height records), are valid at the ship reference point.

This difference in reference frames only becomes an issue in Caris HIPS when applying post-processed navigation and attitude data. The primary reason for post applying any post-processed data is the quality of the vertical information. Delayed heave or a post processed ellipsoid height can both significantly improve on the real time solution, so it is desirable to have the option to apply these adjustments in post processing. While a vertical offset can be straightforward to apply, the valid location of the available vertical positioning data is important for proper accounting for the effects of the motion induced heave.

Caris HIPS is designed around the integration of sensor data described in a single reference frame with one sensor for each type of data. The Hydrographic Vessel File (HVF) describes the offsets between the different sensors being integrated and accounts for those offsets where required. Processing Kongsberg multibeam data within this framework is complicated by the existence of two possible reference frame existing within the provided data. While in general Kongsberg data is meant to provide all data in the vessel reference frame (patch test values are applied to motion information, ray traced soundings, etc), real time heave and all raw transducer data (ranges and angles) are also provided in the transducer reference frame. The Caris HVF accounts for this dual state by not applying any motion (everything is apply = no) or offsets (Swath offsets are zero) when the real time ray-traced solution is imported, but does account for these offsets or motion when reprocessing during ray tracing (SVC). This is the reason for the transducer lever arms provided in the SVP portion of the HVF. In theory reintegrating the motion information is straightforward because all lever arms and angular offsets have already been applied to the Kongsberg data. Problems do arise when the data provided in post processing are not in the same reference frame as the Kongsberg frames. In our case, delayed heave or GPS height information. HIPS can handle different configurations, but a different HVF may be required depending on the sensor and workflow (e.g., SVC or no SVC, true heave or real time heave). Most significant to this discussion of the HVF configuration is the description of the heave sensor location- as configured, the real-time heave is reported in a different place than the delayed heave, but there is only one ‘heave’ field in the HVF.

It would seem the logic of the HVF would require a lever arm for the heave sensor when using Kongsberg real time heave (Kongsberg reported heave has the induced heave included and is therefore valid at the transducer as mentioned previously), but the HVF requires no offset for the heave sensor when reintegrating the real time heave during SVC. All other data is either valid at the reference point or has offsets as described by the Caris technote on converting Kongsberg data [8]. This inherently calls into question the reference frame of the HVF for Kongberg data – is the HVF in the vessel reference frame or the transducer reference frame? When conducting SVC in HIPS the reference frame appears to be in the transducer reference frame (with the exception of the SVP fields). When no SVC is conducted the reference frame appears to be in the vessel reference frame.

When no SVC is conducted, the description of the heave sensor lever arm is only important for computing GPS Tides. For the proper removal of heave from the GPS tide height, the HVF heave sensor field must have a lever arm equivalent to the distance from the reference point to the transmit transducer. When computing GPS Tides the “MRU remote heave” box must be checked such that the heave is moved back to the reference point and properly applied to the GPS height. While this is essentially the desired workflow, i.e. all data is to the ellipsoid using all real time data, this method was deemed too inflexible since it precluded a water level referenced workflow free from heave artifacts. Because the position of the heave sensor is ambiguous (real time heave is at the transducers but delayed heave is at the reference point), there is not a way to apply delayed heave during merge only in HIPS. While the difference between real time and delayed heave is the same everywhere on the vessel, this difference needs to be computed at the same location such that the induced heave is canceled out. It is possible to compute this difference directly from the Applanix True Heave record where both the real and delayed heave are reported, but HIPS differences the delayed heave with the real time heave from the Kongsberg file which adds back the induced heave artifact.

When SVC is conducted in HIPS the HVF appears to describe the sensors in the transducer reference frame. SVC may be conducted with zero offsets for all sensors besides the transducers, and results comparable to the real time reported values are produced. The computation of GPS Tides is complicated by the fact that the valid location of GPS tides is at the reference point and not at the transducer, and there is no entry in the HVF for the location of GPS Tides. To circumvent this problem delayed heave must be applied to the data. By including an entry in the HVF that describes the location of the reference point, and thereby delayed heave, for the heave sensor relative to the transmit transducer, heave is correctly applied to the bathymetry. This means a lever arm *opposite* to the SVP1 field is entered for the heave sensor and provides for an SVC inclusive workflow that references the survey to the waterline. To compute GPS tides the “MRU remote heave” box is *not* check because delayed heave and the GNSS height are both already at the reference point. While this workflow requires delayed heave and the SVC step in post processing, it provides for the most flexible workflow and is recommended for *Thomas Jefferson* with their current configuration.

The application of “Waterline” during the computation of GPS tides also deserves discussion here. If data are converted with the GPS Height as GGK then the waterline needs to be applied during GPS Tide.

Because SIS applies the waterline value from the Installation Parameters to the EM Height, if the data are converted with GPS Height as EM Height the water line does not need to be applied when computing GPS tides. For this reason the recommended workflow for *Thomas Jefferson* is to convert with EM Height but not apply waterline during the GPS Tide computation.

While much of this confusion could be alleviated if Caris accommodated multiple potential heave sensor (e.g. real-time, post-processed) within the HVF (i.e. the real time Kongsberg reported heave required a lever arm entry), Caris stated in the helpdesk ticket while exploring this problem that their HVF configuration will not be revisited until Caris HIPS 11. For a discussion of this solution please see the NOAA - Caris helpdesk ticket request ID 01602680.

To accommodate the current processing restrictions, maximize potential workflow flexibility, and limit the number of unique HVF files, we implemented the following workflows:

1) ERS
    a. Convert MBES data → Load Delayed Heave → Sound Velocity Correct → Compute GPS Tides → Merge with GPS Tides → TPU

2) Traditional Water Levels
    a. Convert MBES data → Load Delayed Heave → Load Tides → Sound Velocity Correct → Merge → TPU

Thomas Jefferson's HVF has also been modified to account for Total Propagated Uncertainty (TPU) with MarineStar (which does not have real time uncertainty reported correctly), but again to maximize flexibility while limiting unique HVFs. Entries associated with the real time water level reference uncertainty, such as heave, static and dynamic draft, which together have a root sum square value of 0.09 m, have been removed from the HVF. When surveying to the ellipsoid, a value of 0.11 m for the MarineStar uncertainty is entered into the Tide/Measured dialog. This value was derived as an average of all 2015 *Thomas Jefferson* ship (no launches) POSPac PPP projects compiled by Physical Scientist Faulkes. The VDatum uncertainty from the project instructions is entered into the Tide/Zoning dialog. When surveying to the waterline, the Tide/Measured dialog will include the values that were removed from the HVF as a single value of 0.09 m, and the projects instructions will inform the value for the Tide/Zoning dialog.

For details, please see the Standard Operating Procedure for *Thomas Jefferson's* Caris HIPS configuration and conversion in the appendix.

7.2 Test data resolution and density

As with past Kongsberg multibeam echo sounders, *Thomas Jefferson's* survey system meets Coast Survey sounding density specifications. The density estimates, as calculated from the extinction lines, for the EM2040 can be found in Figure 70, and the EM710 in Figure 72. Ping rates as measured from these same data can be found in Figure 71 and Figure 73 for the EM2040 and EM710 respectively. Unfortunately, the EM2040 extinction was not tested specifically in shallow water where the density estimate would be most applicable. Past testing with the EM2040 [10] demonstrates that the EM2040 will meet NOAA density specifications in shallow water.

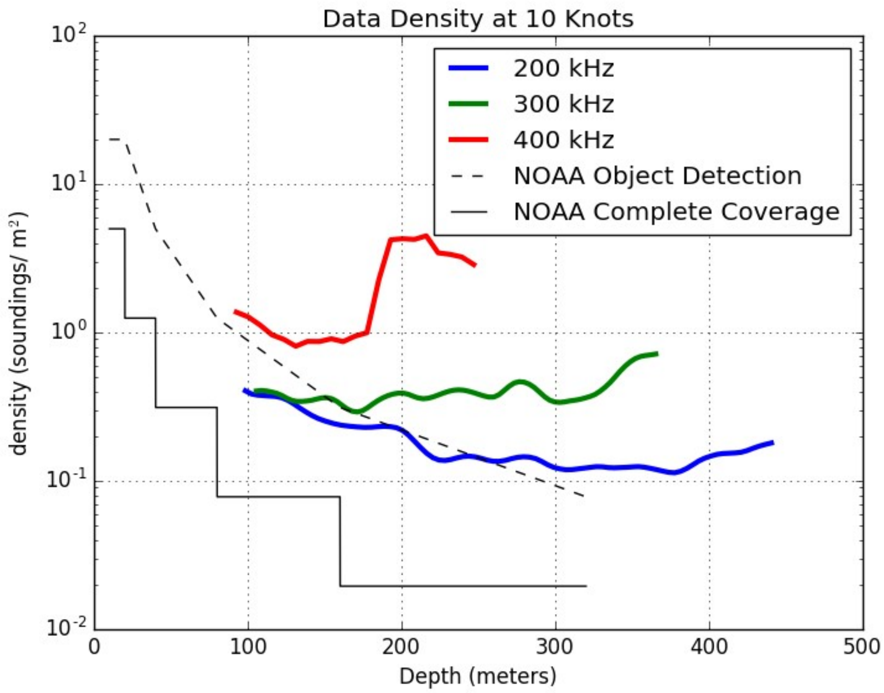


Figure 70 – Sounding density for the EM2040 estimated from the extinction lines.

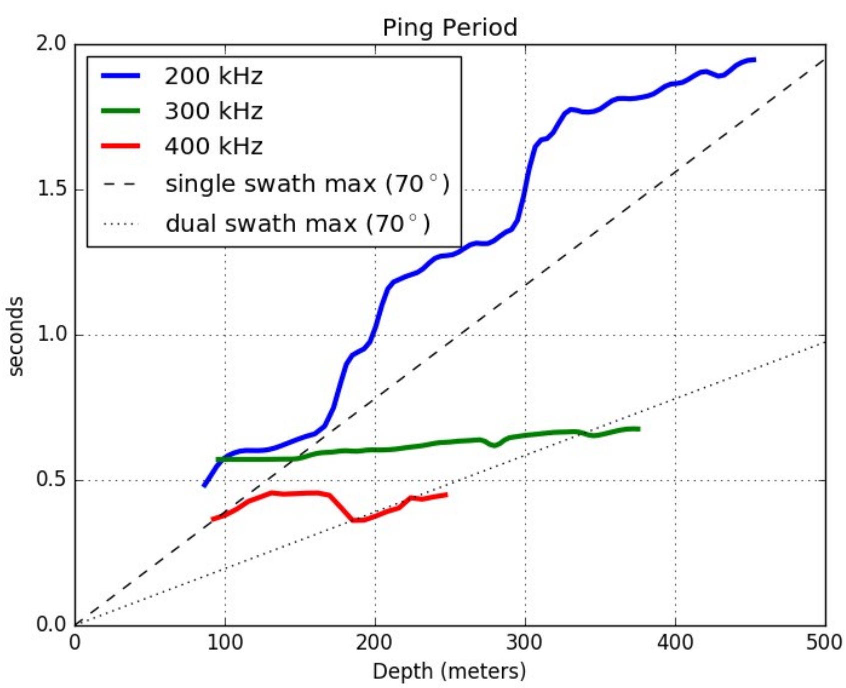


Figure 71 – Ping periods for the EM2040 during the extinction lines.

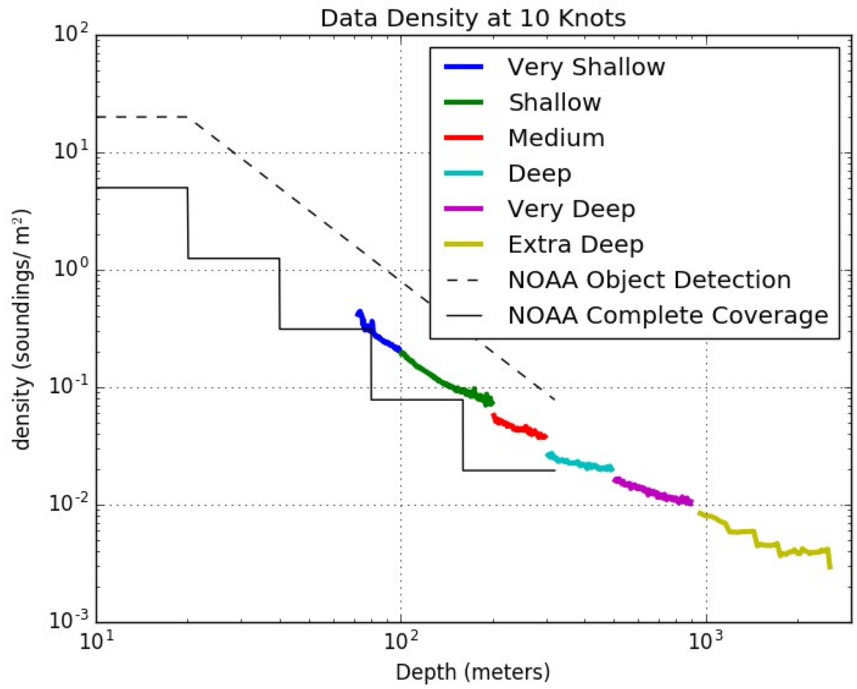


Figure 72 – Sounding density for the EM710 estimated from the extinction lines.

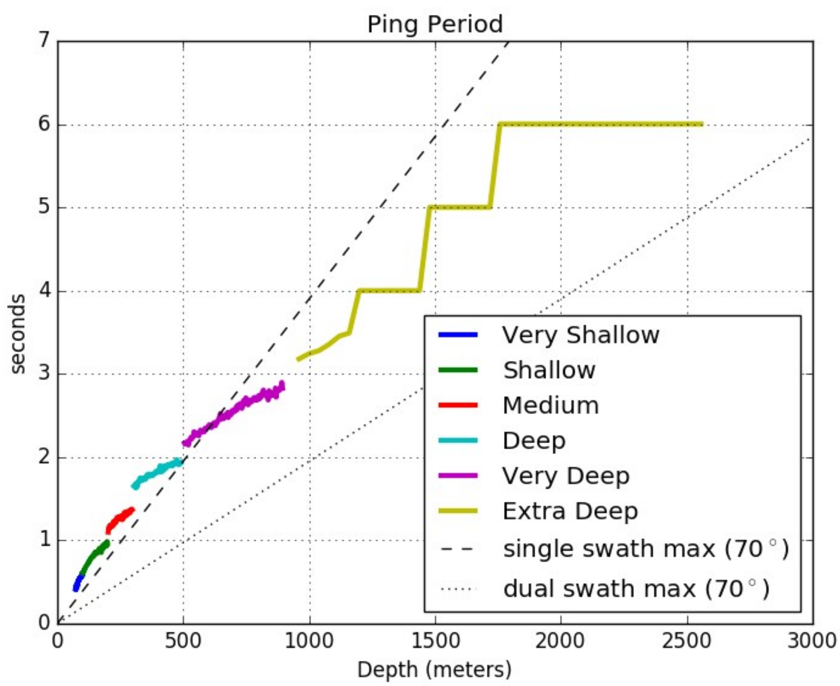


Figure 73 – Ping period for the EM710 during the extinction lines.

7.3 Test total propagated uncertainty

Kongsberg produces real time uncertainty for the echo sounder component of the uncertainty model according to the method recommended by Ifremer [9]. These records can be ingested by Caris to contribute toward the sonar portion of the Total Propagated Uncertainty (TPU). Data were evaluated using data collected during the object detection portion of this cruise and using the HIPS configuration described in 7.1. For reference, IHO Order 1a for 75 meters of depth is 1.1 meters. At nadir the uncertainty was 0.406 meters, and for the outer beams it was 0.737 meters.

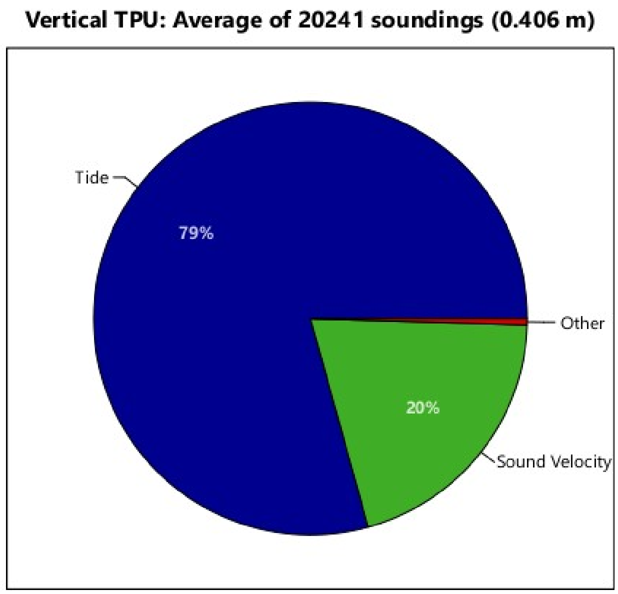


Figure 74 - Nadir Total Vertical Uncertainty breakdown by contribution source for the EM2040. The real time uncertainty from the echo sounder is small and included in the "Other" portion of the plot.

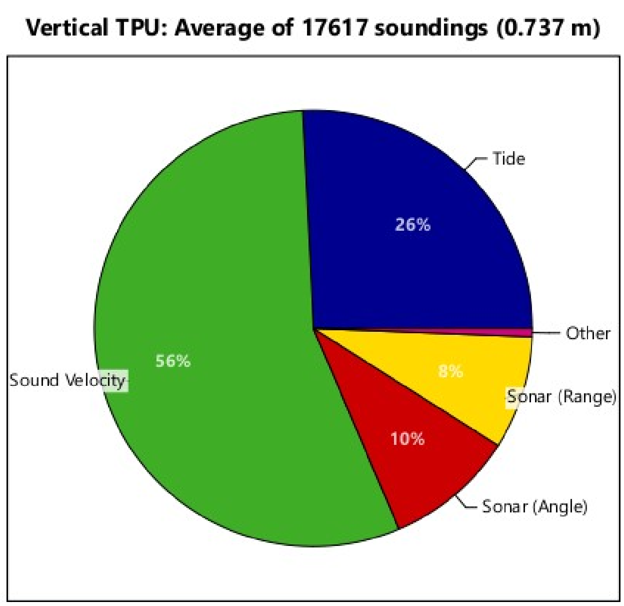


Figure 75 – Outer beam Total Vertical Uncertainty breakdown by contribution source for the EM2040. The contribution from the echo sounder real time uncertainty is small relative to other factors.

Both Figure 74 and Figure 75 demonstrates that the EM2040 real time echo sounder uncertainty is not a major contributor to the total uncertainty and that the Caris HIPS configuration can be expected to meet IHO Order 1a specifications for uncertainty.

7.4 Difference Surface

The object detection lines from the vicinity of the wreck of the Bow Mariner were used to compare the fully integrated EM710 and EM2040 survey depths against previous data collected by NOAA Ship *Thomas Jefferson* during survey F00585. All *Thomas Jefferson* acceptance survey data was collected to the ellipsoid, so an offset between ITRF 2008 and mean lower low water of -38.6 meters at the Bow Mariner location was computed using VDatum. This offset was used to shift data to the same datum as the previous *Thomas Jefferson* survey. The difference surface statistics between the previous Reson 7125 and the new EM710 and EM2040 are described in Table 6. Also included in this table are difference surface statistics between *Thomas Jefferson's* EM2040 and survey H11504 by David Evans and Associates, which happened to cover some preliminary data collected with the new EM2040 before the acceptance cruise. Patch test values were applied in post processing for these data, and the sound speed cast was adjusted to account for the faulty sensor present during preliminary testing (see 4.2.3).

Table 6 - Difference surface statistics as computed within Caris HIPS.

Location and System	Mean Offset (m)	Standard Deviation (m)
Bow Mariner – EM710	-0.3	0.2
Bow Mariner – EM2040	-0.2	0.1
Chesapeake Bay – EM2040	0.2	0.1

While there appears to be a consistent bias at the Bow Mariner site compared to the previous Reson 7125 survey data, there is good agreement between the *Thomas Jefferson* EM710 and the EM2040. When considering this agreement with the opposing offset in the difference between previous survey coverage and Thomas Jefferson's EM2040 at the two different locations, the bias may not be due to an offset internal to the survey system but in realizing the vertical datum. The uncertainty in realizing the vertical datum (VDatum and the MarineStar Service) is approximately 0.14 meters at two standard deviations. Since the mean uncertainty for the F00585 and H11504 surveys were 0.55 meters and 0.41 meters respectively (both vertically referenced through tide zoning), *Thomas Jefferson* appears to be configured to produce properly vertically referenced soundings with the new survey system.

8 Concluding Summary

Two new Kongsberg multibeam echo sounders have been added to the NOAA Hydrographic fleet aboard NOAA Ship *Thomas Jefferson*. While the EM710 and EM2040 appear to be functioning as specified and are integrated with the supporting sensors correctly, two residual problems remain.

The primary problem is a leeward bathymetric artifact effecting both the EM2040 and EM710. While an initial step to remedy this problem has been taken by removing the line guard in front of the transducer mount, further testing is required to evaluate if the problem is resolved. If the problem is not resolved further steps will need to be taken to better characterize the source of the problem and engineer a fix.

The second problem is an artifact with the EM2040 200 kHz mode. Kongsberg recommendations to resolve this problem have already been implemented and testing is required to understand if the issue persists.

Thomas Jefferson has a workflow that will provide both ellipsoid and water level derived results in Caris HIPS. While this workflow unfortunately does not take advantage of the real time GPS height and ray traced bathymetry, it does meet the requirements of the ship despite being more cumbersome.

The EM2040 Min Depth detection mode was compared to the Normal detection mode and found to improve the recognition of features that reflect man made construction. While this mode is useful for developments, it should not be used for general bathymetry to avoid collecting data on fish schools.

Acknowledgements

We would like to recognize the ship and CDR Moser for their struggle and effort to get underway and operate the ship in new ways after being land bound for six months. The flexibility and hard work of the acceptance crew is also recognized. Jack Riley was particularly instrumental in producing some of the plots for this report and also, in addition to LCDR Sam Greenaway and John Doroba, for helping get the Caris HIPS workflow sorted out. The help of Eric Younkin and Matt Wilson in alongside preparation was also appreciated.

9 References

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[9] X. Lurton and J.M. Augustin, “A Measurement Quality Factor for Swath Bathymetry Sounders,”, IEEE J. of Ocean. Eng., Vol 35, No. 4, Oct, 2010.

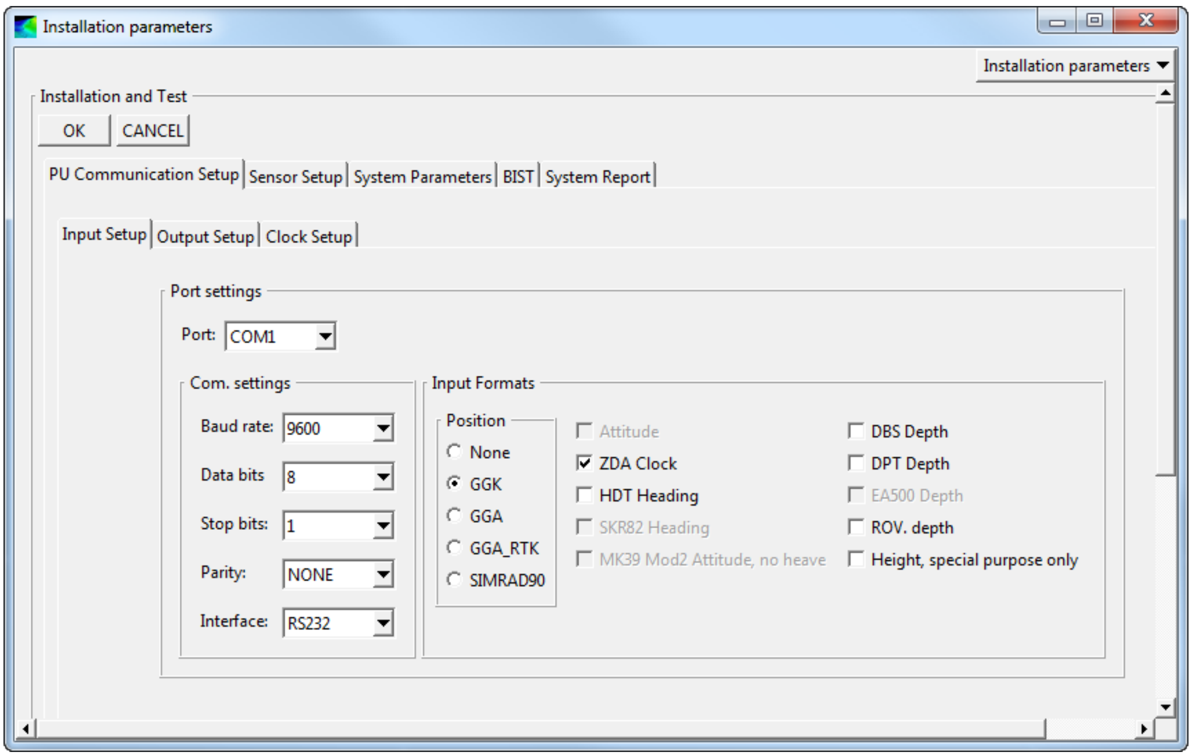
[10] G. Rice, “Bay Hydrographer II EM2040 Testing of Acceptance Testing,” NOAA Office of Coast Survey, Silver Spring, MD, Tech Rep, 2016.

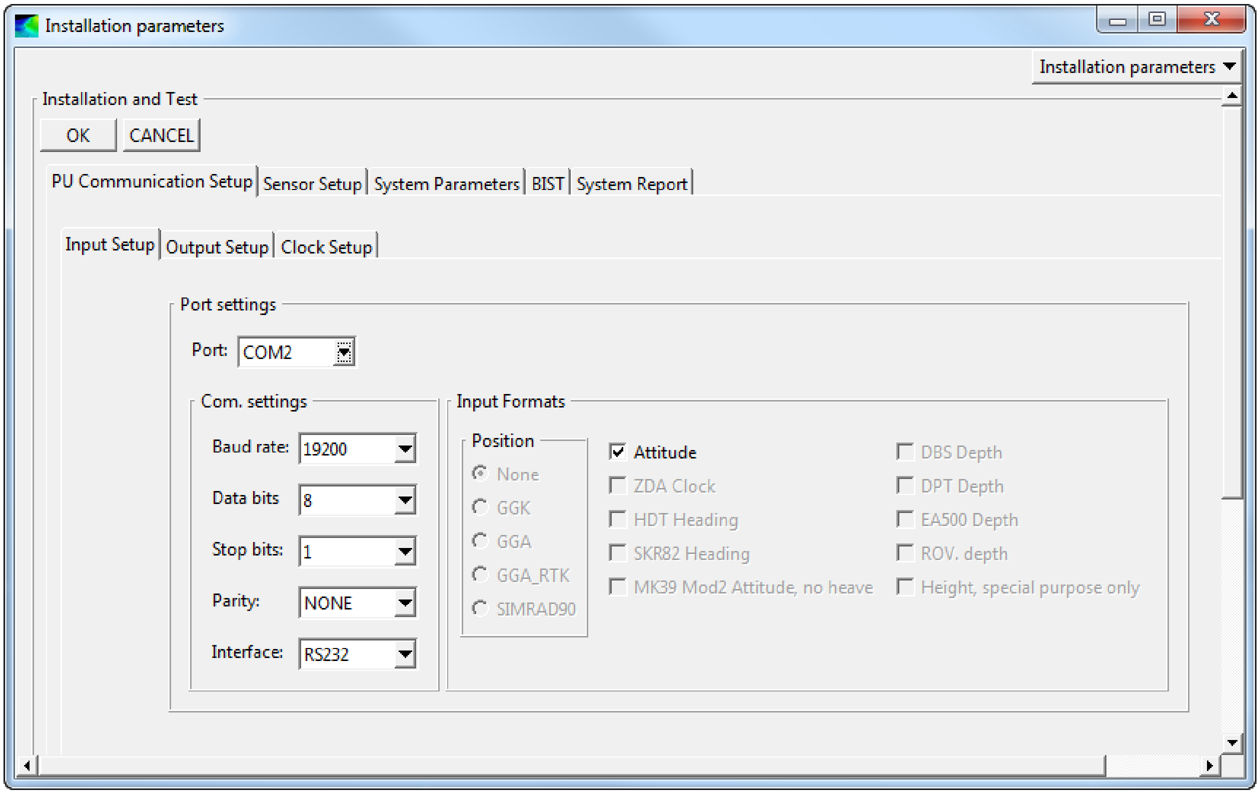
10 Appendices

10.1 Configuration Screen Grabs

10.1.1 SIS

10.1.1.1 EM2040

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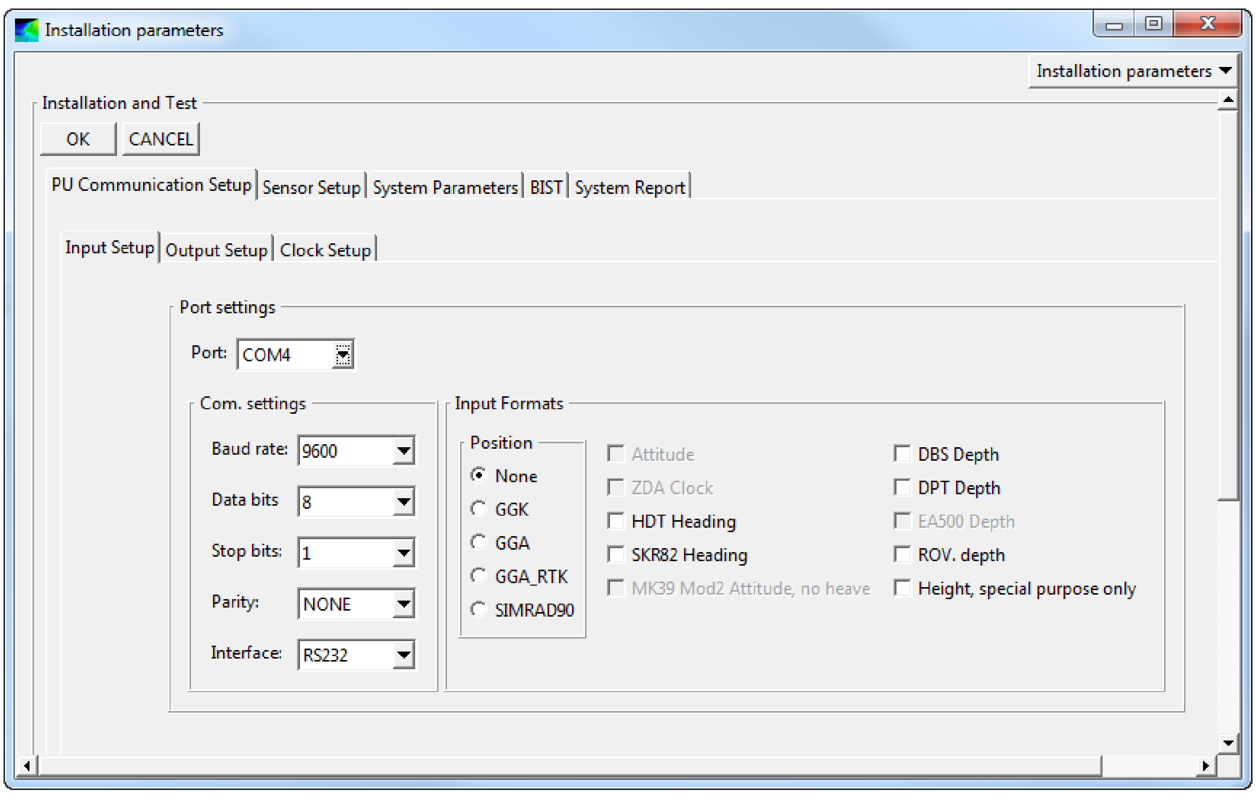
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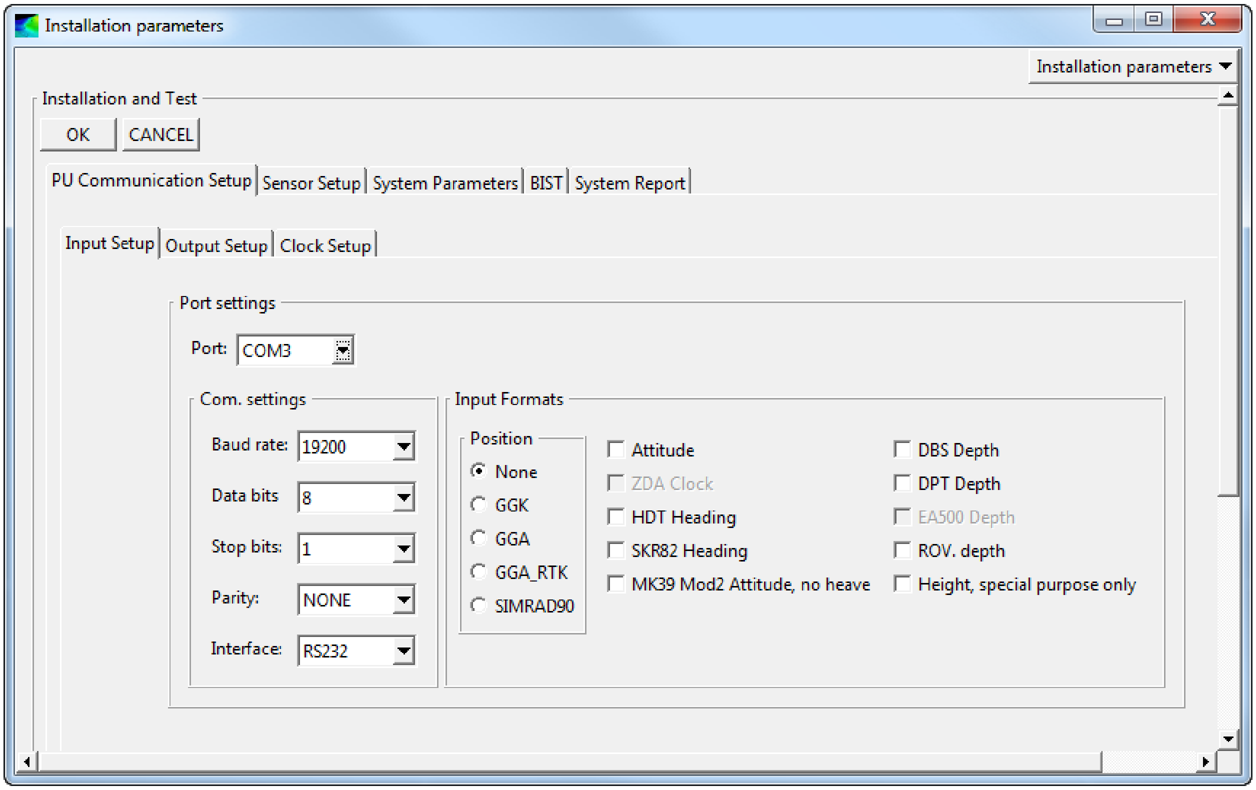
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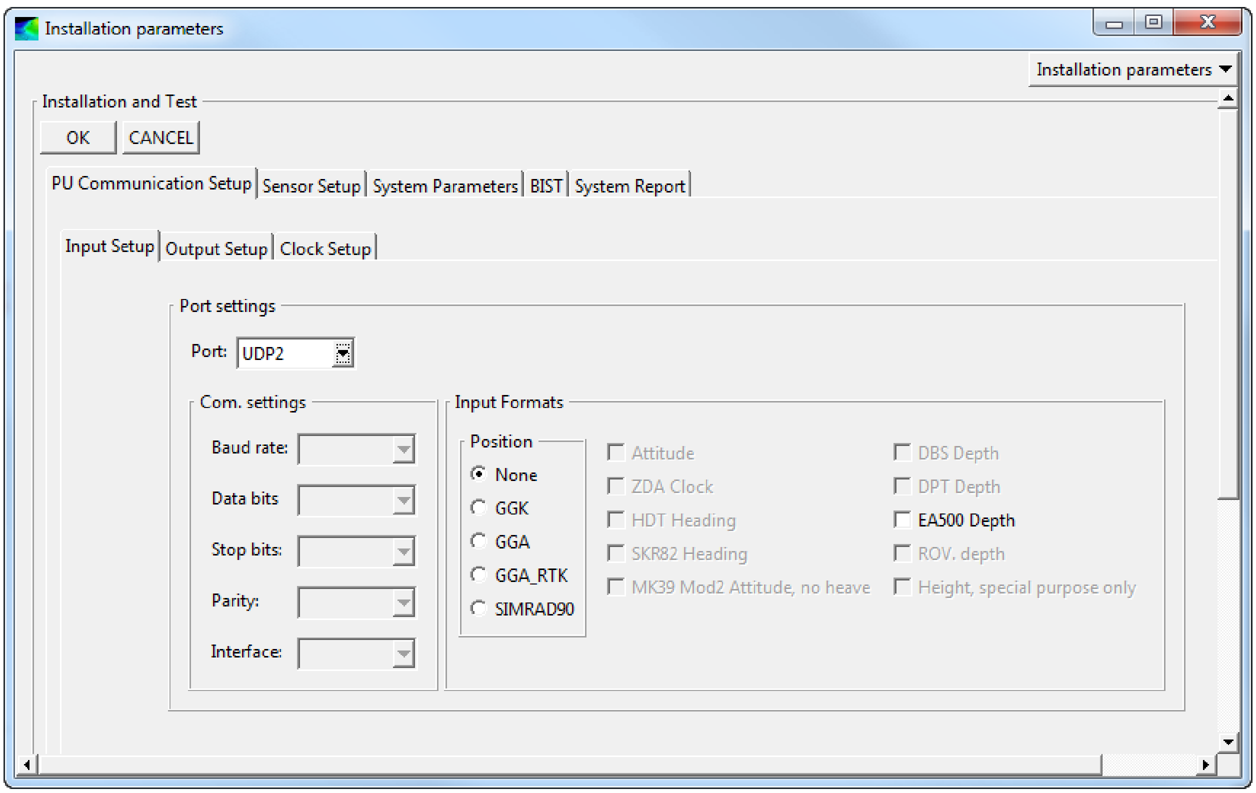
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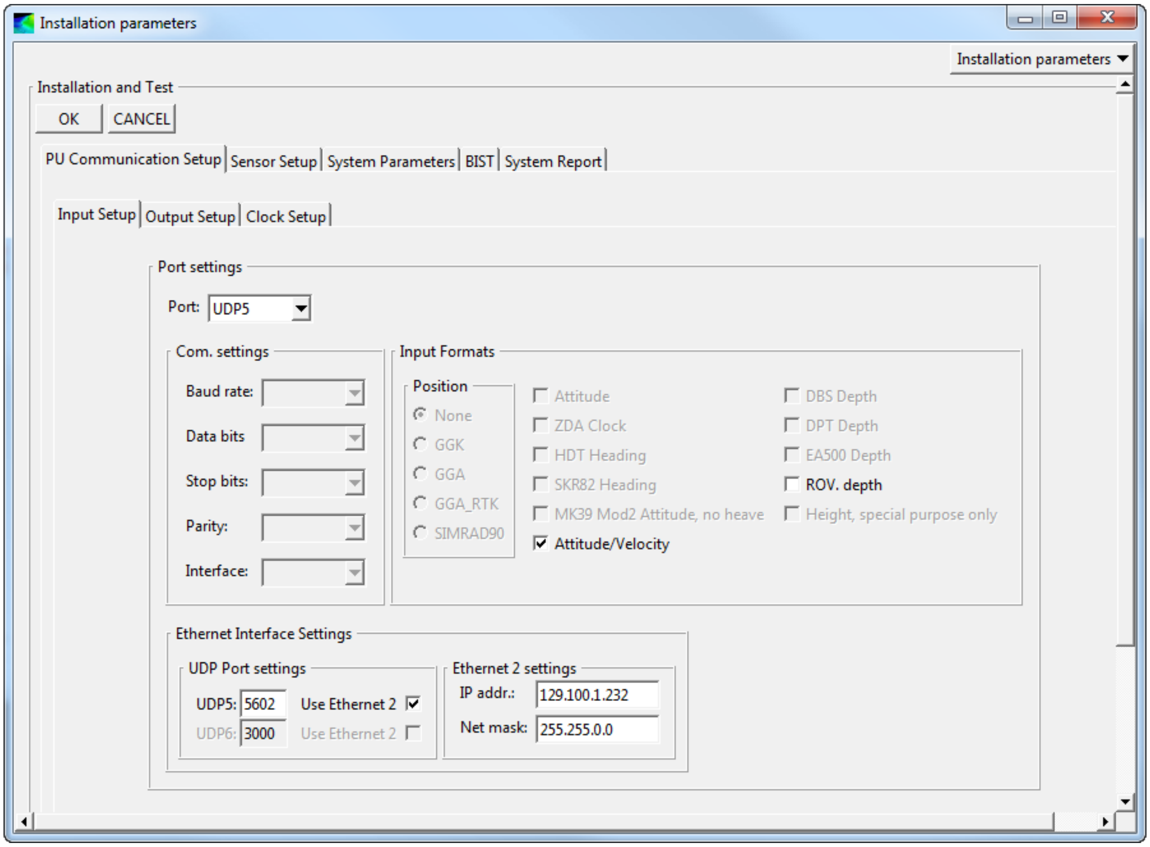
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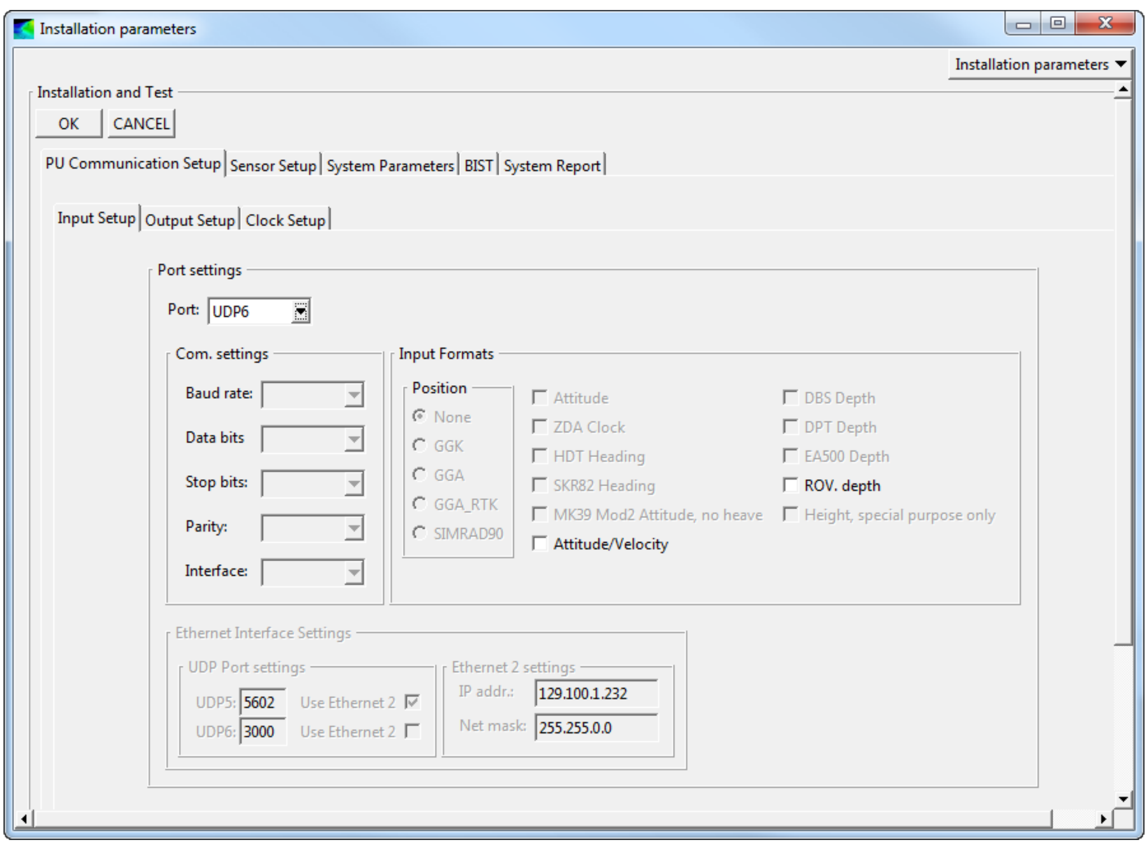
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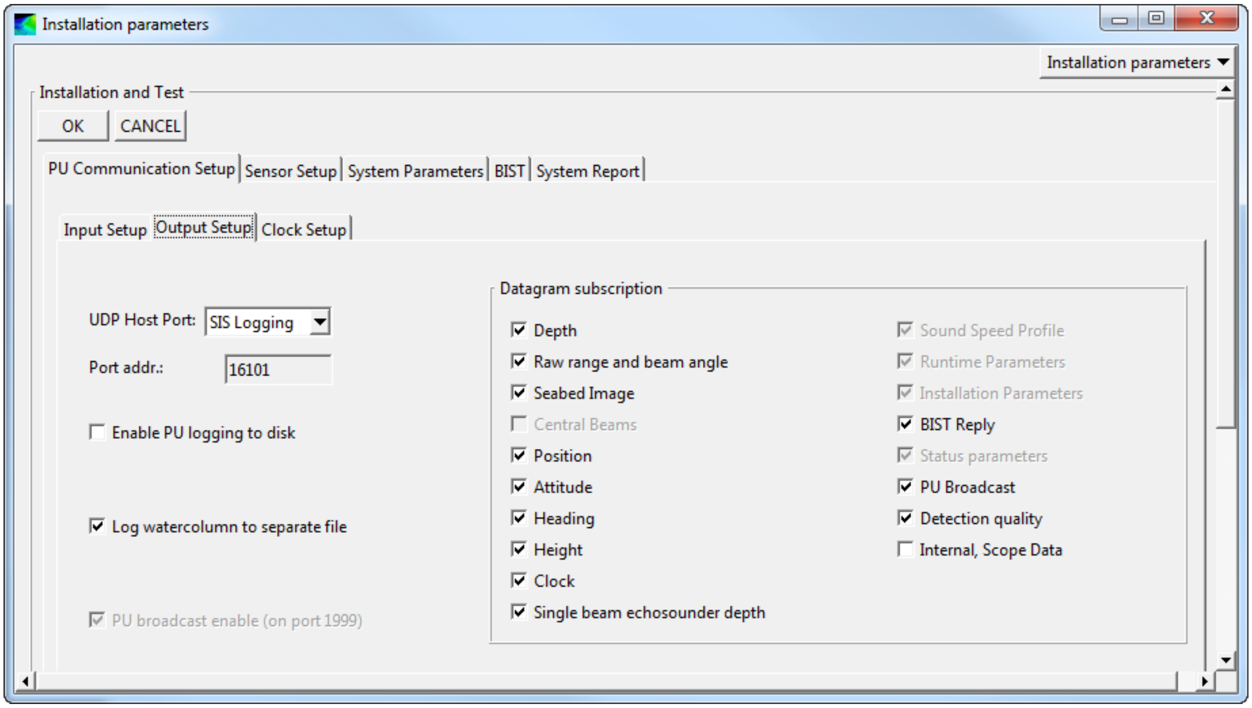
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Seabed Image
Central Beams
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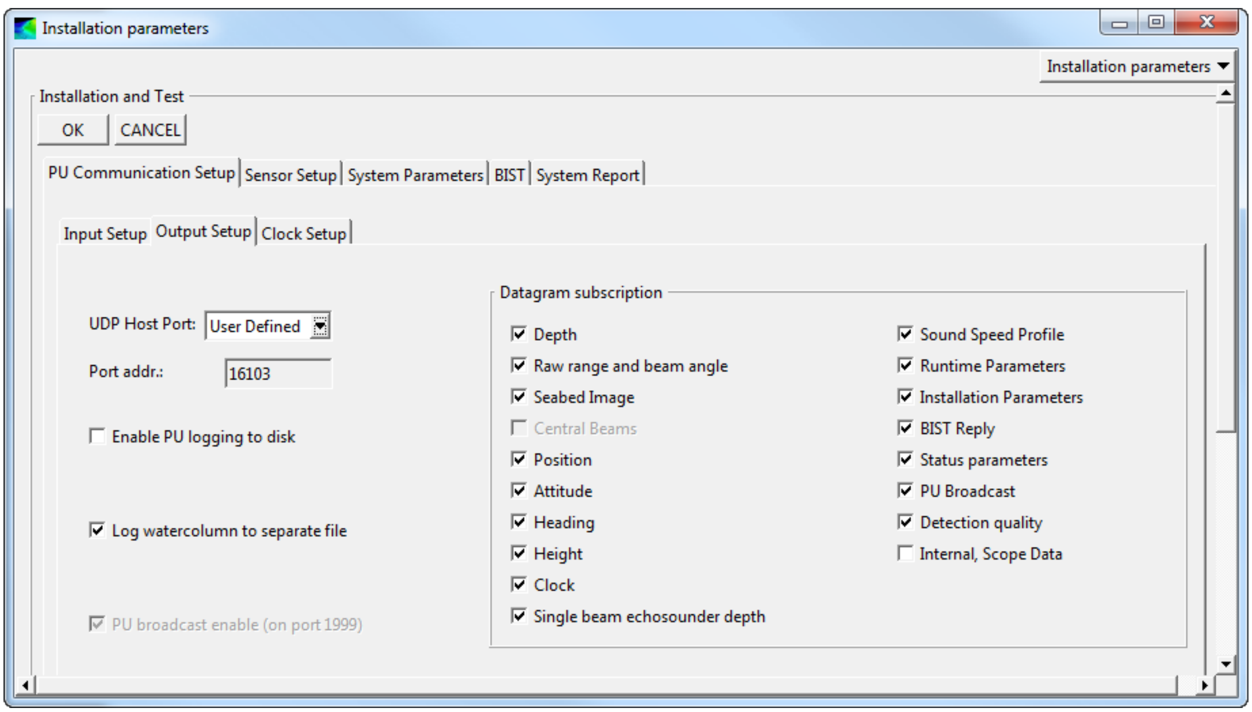
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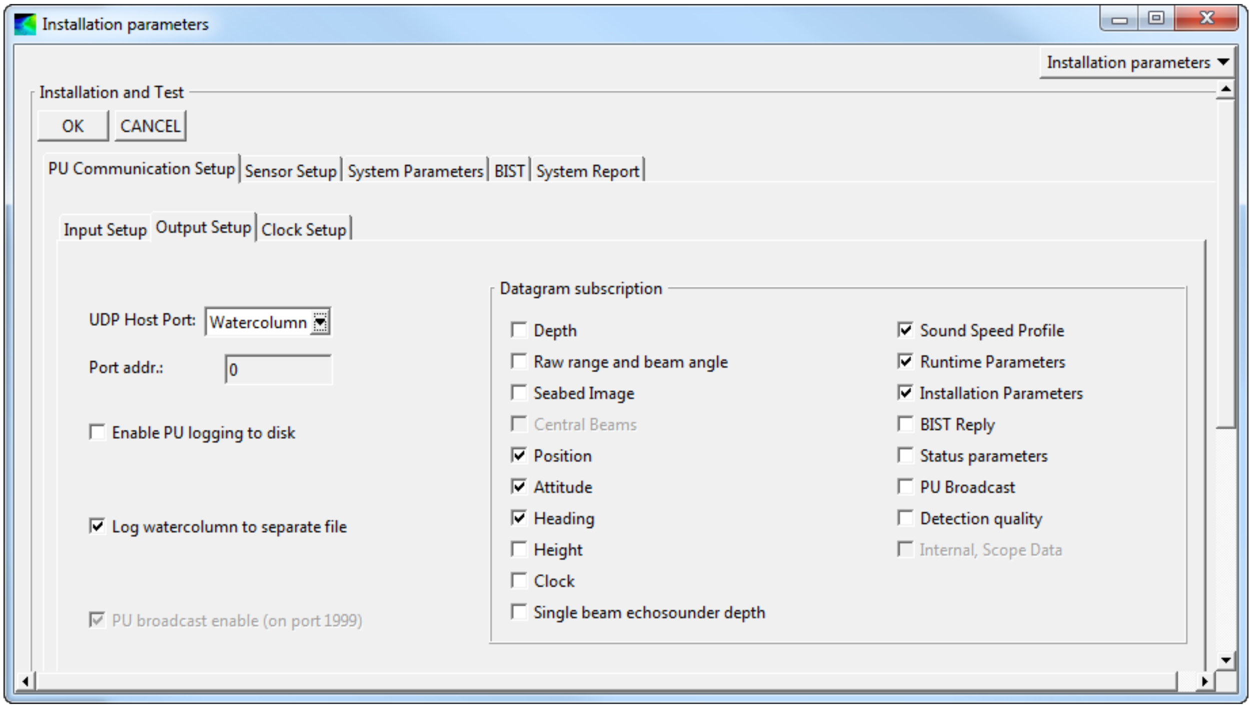
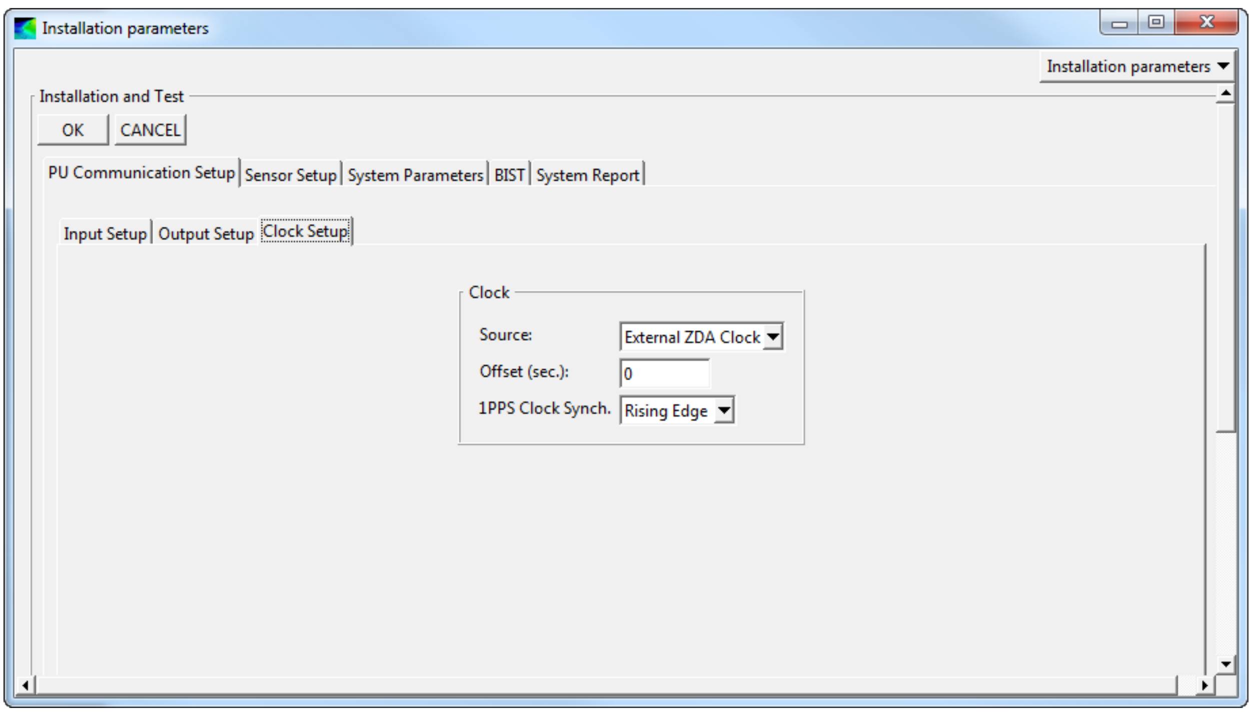
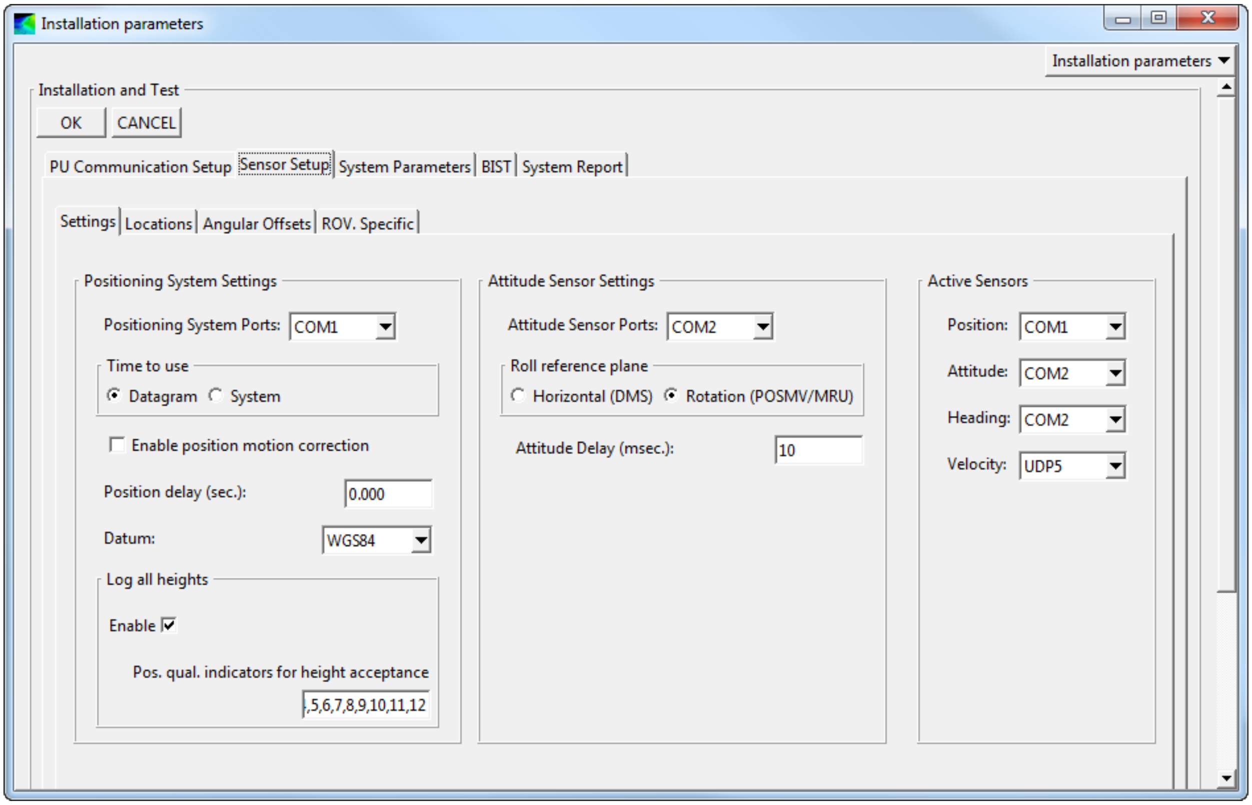
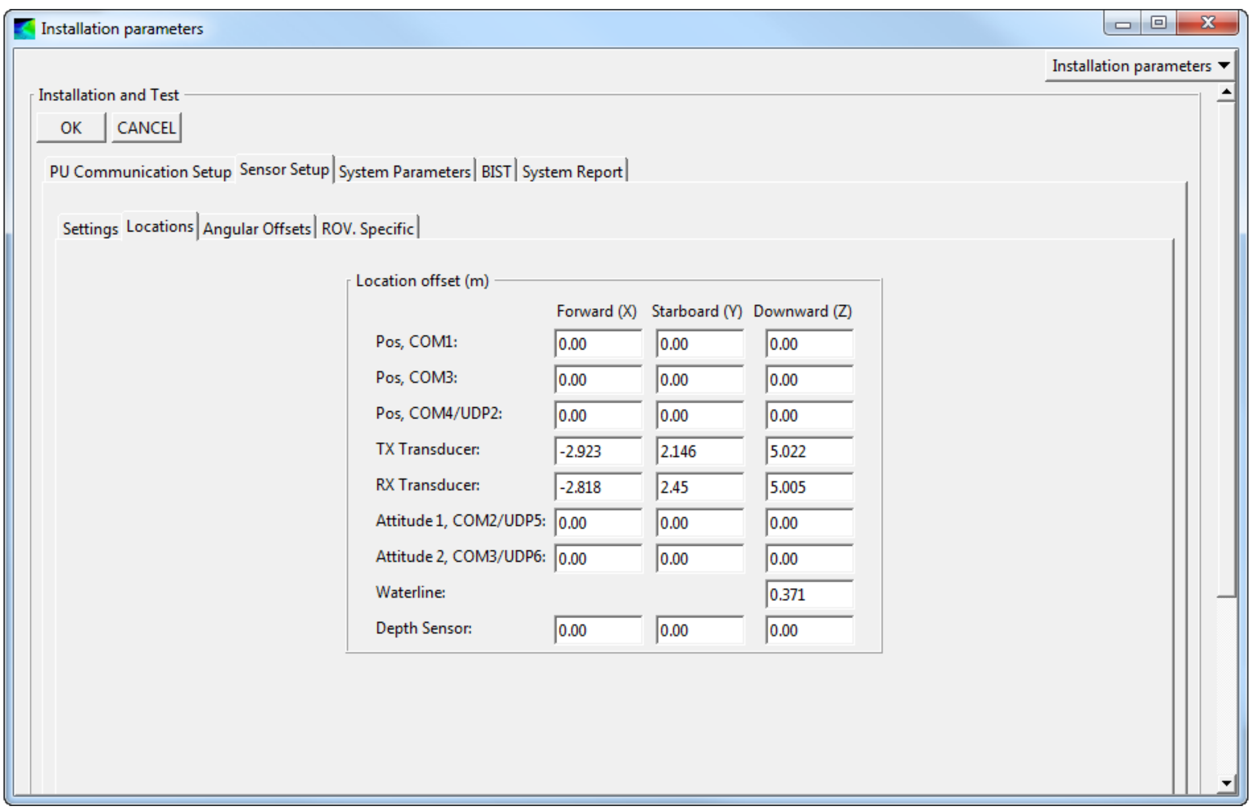
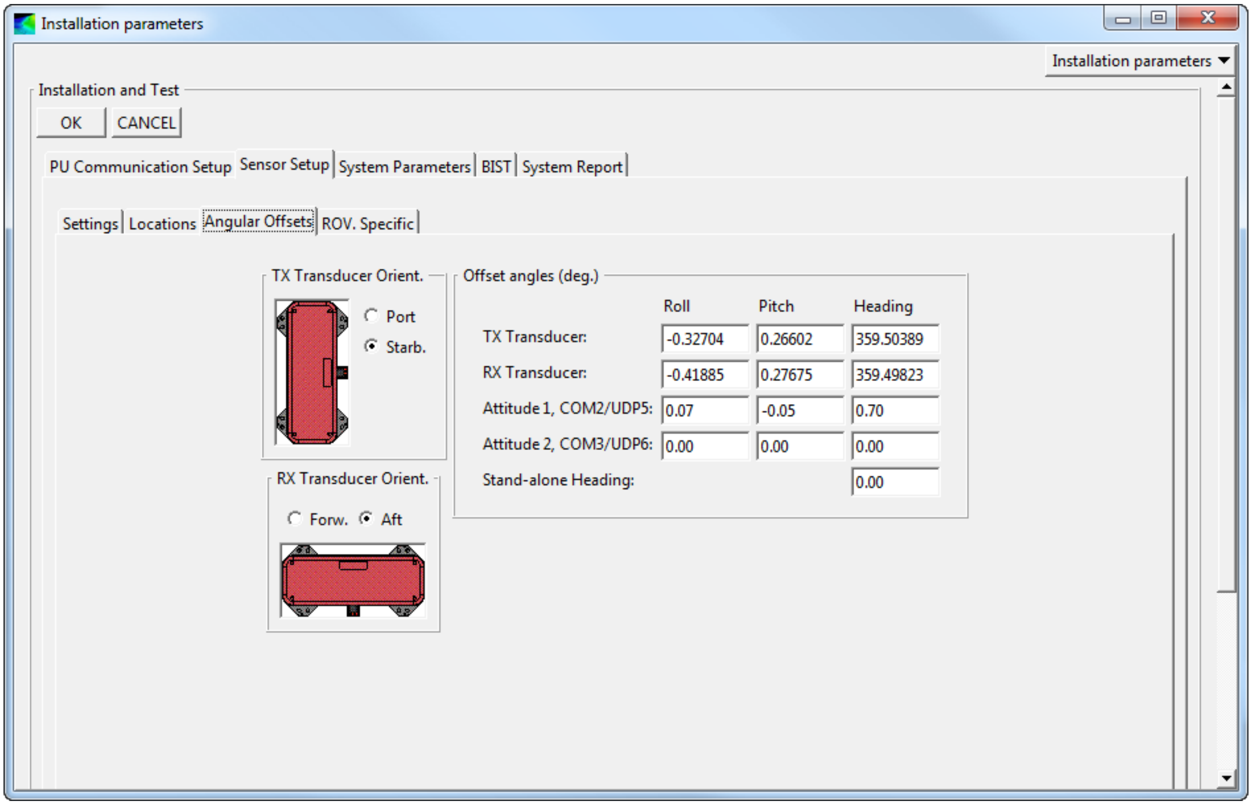
Clock
Single beam echosounder depth
Sound Speed Profile
Runtime Parameters
Installation Parameters
BIST Reply
Status parameters
PU Broadcast
Detection quality
Internal, Scope Data

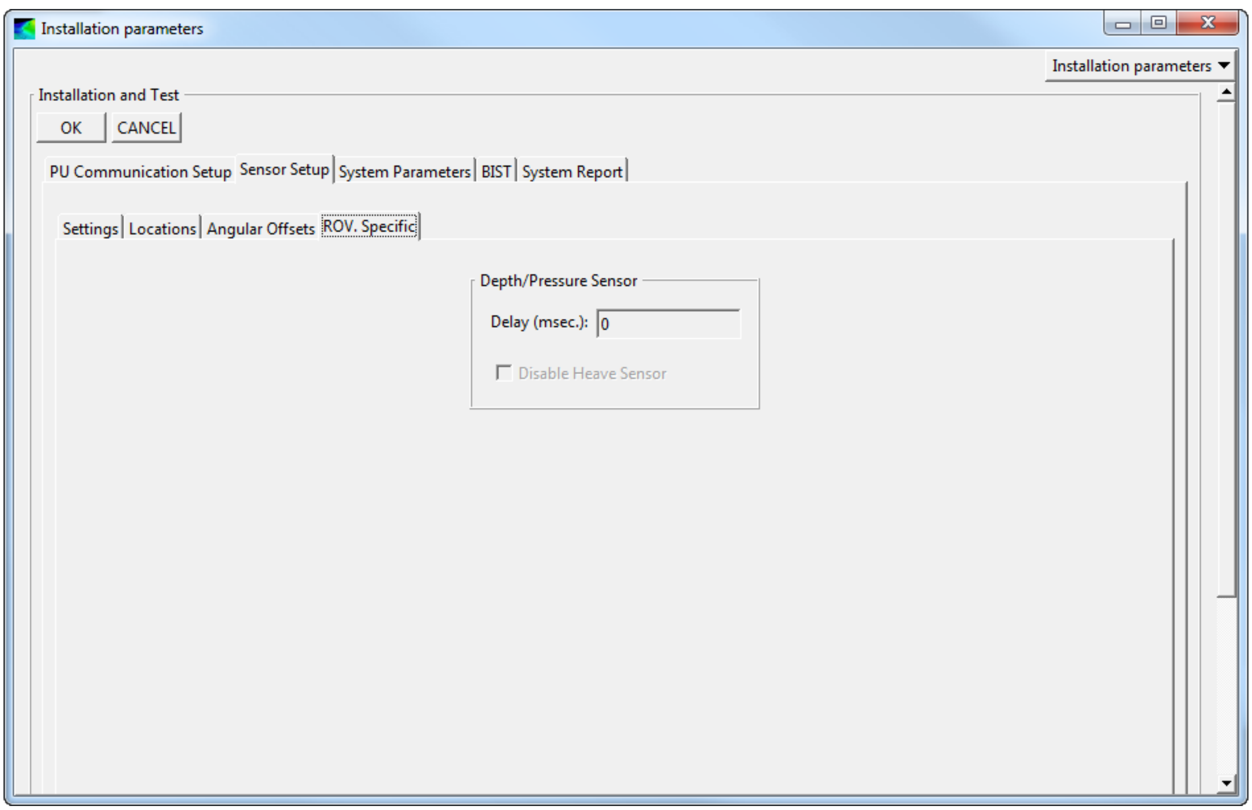

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
UDP Host Port:
Watercolumn
Port addr.:
0
Enable PU logging to disk
Log watercolumn to separate file
PU broadcast enable (on port 1999)
Datagram subscription
Depth
Raw range and beam angle
Seabed Image
Central Beams
Position
Attitude
Heading
Height
Clock
Single beam echosounder depth
Sound Speed Profile
Runtime Parameters
Installation Parameters
BIST Reply
Status parameters
PU Broadcast
Detection quality
Internal, Scope Data

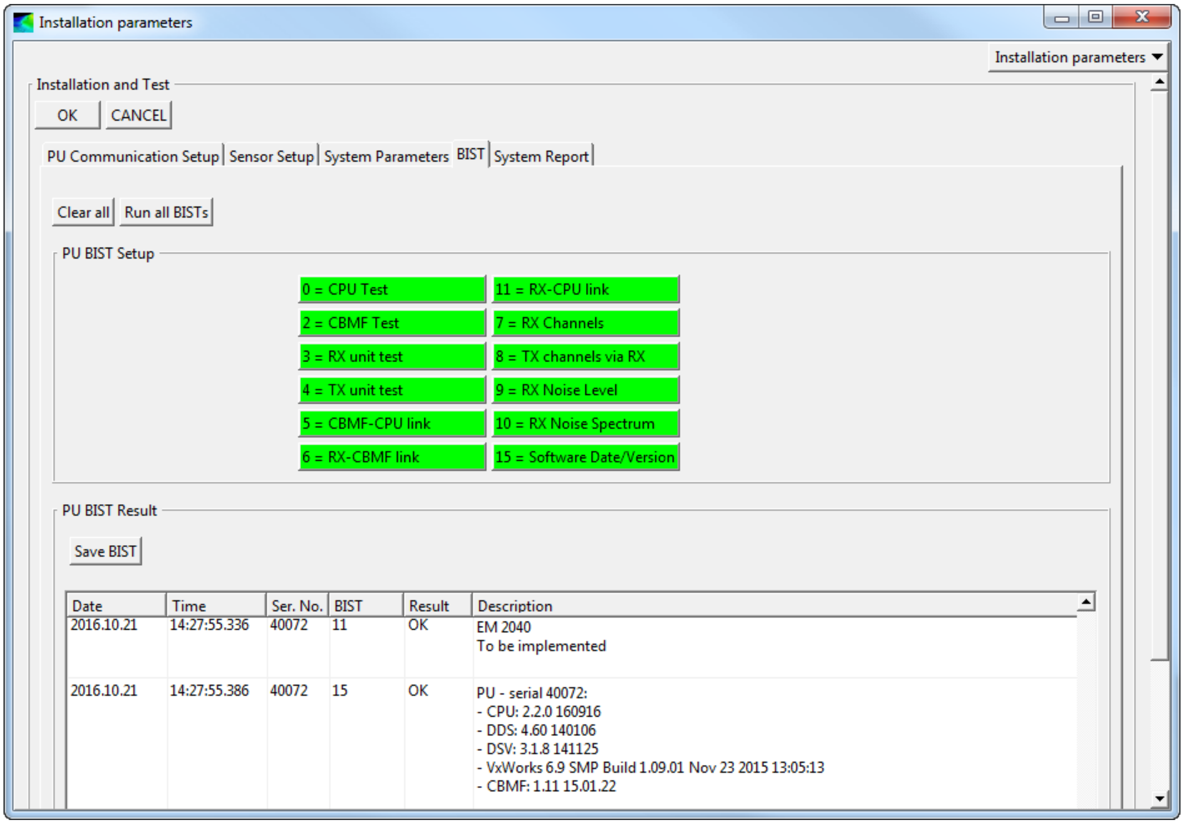

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
Clock
Source:
External ZDA Clock
Offset (sec.):
0
1PPS Clock Synch.
Rising Edge

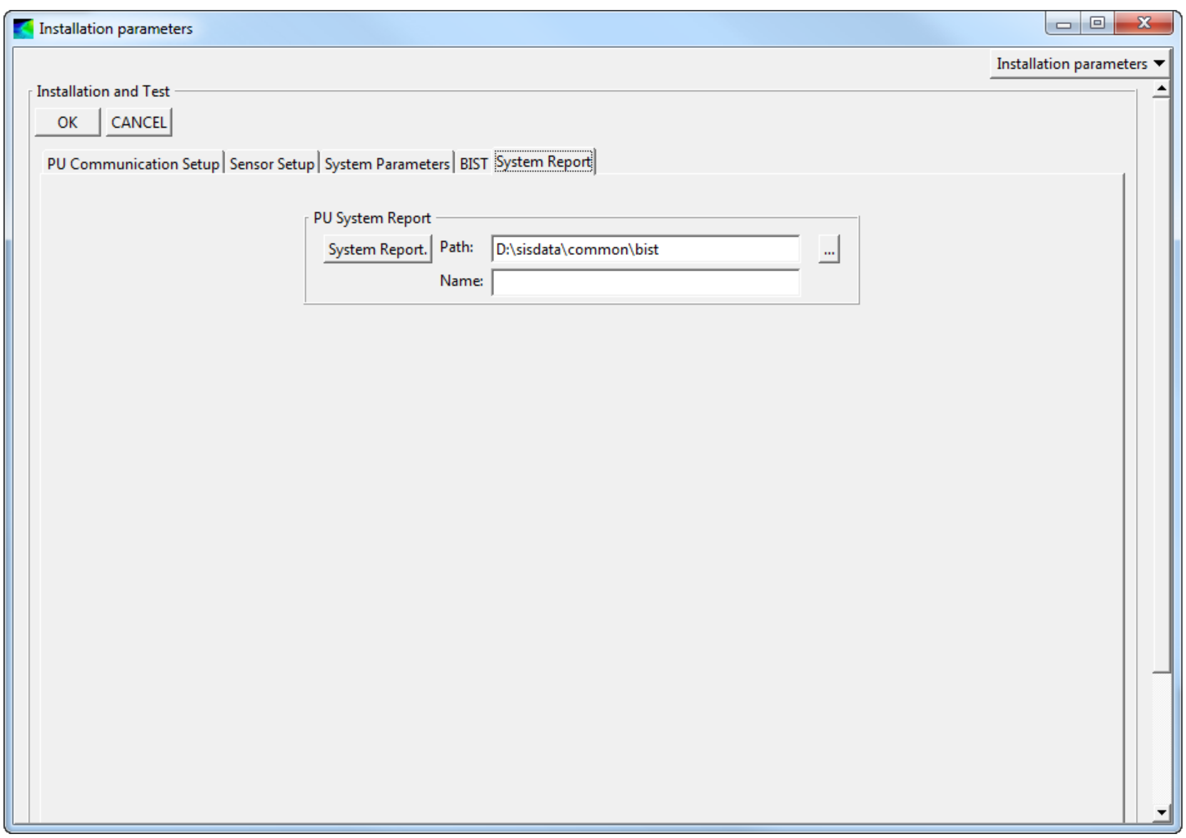

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Settings
Locations
Angular Offsets
ROV. Specific
Positioning System Settings
Positioning System Ports:
COM1
Time to use
Datagram
System
Enable position motion correction
Position delay (sec.):
0.000
Datum:
WGS84
Log all heights
Enable
Pos. qual. indicators for height acceptance
,5,6,7,8,9,10,11,12
Attitude Sensor Settings
Attitude Sensor Ports:
COM2
Roll reference plane
Horizontal (DMS)
Rotation (POSMV/MRU)
Attitude Delay (msec.):
10
Active Sensors
Position:
COM1
Attitude:
COM2
Heading:
COM2
Velocity:
UDP5

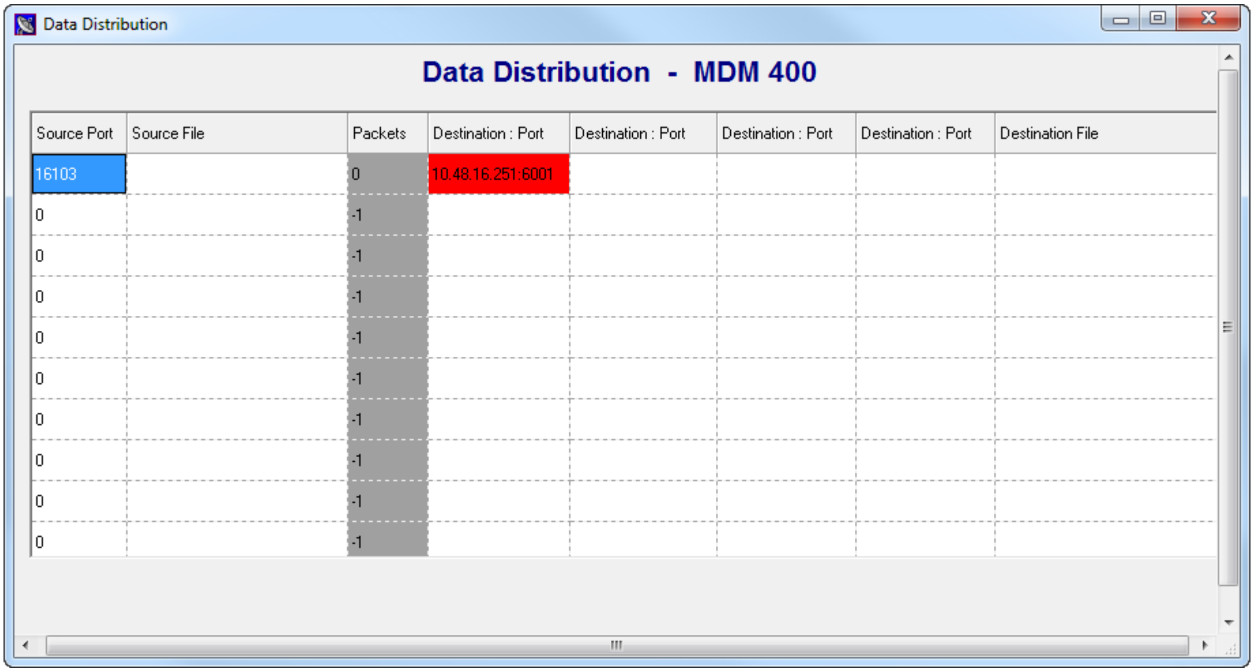

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Settings
Locations
Angular Offsets
ROV. Specific
Location offset (m)
Forward (X)
Starboard (Y)
Downward (Z)
Pos, COM1:
0.00
0.00
0.00
Pos, COM3:
0.00
0.00
0.00
Pos, COM4/UDP2:
0.00
0.00
0.00
TX Transducer:
-2.923
2.146
5.022
RX Transducer:
-2.818
2.45
5.005
Attitude 1, COM2/UDP5:
0.00
0.00
0.00
Attitude 2, COM3/UDP6:
0.00
0.00
0.00
Waterline:
0.371
Depth Sensor:
0.00
0.00
0.00

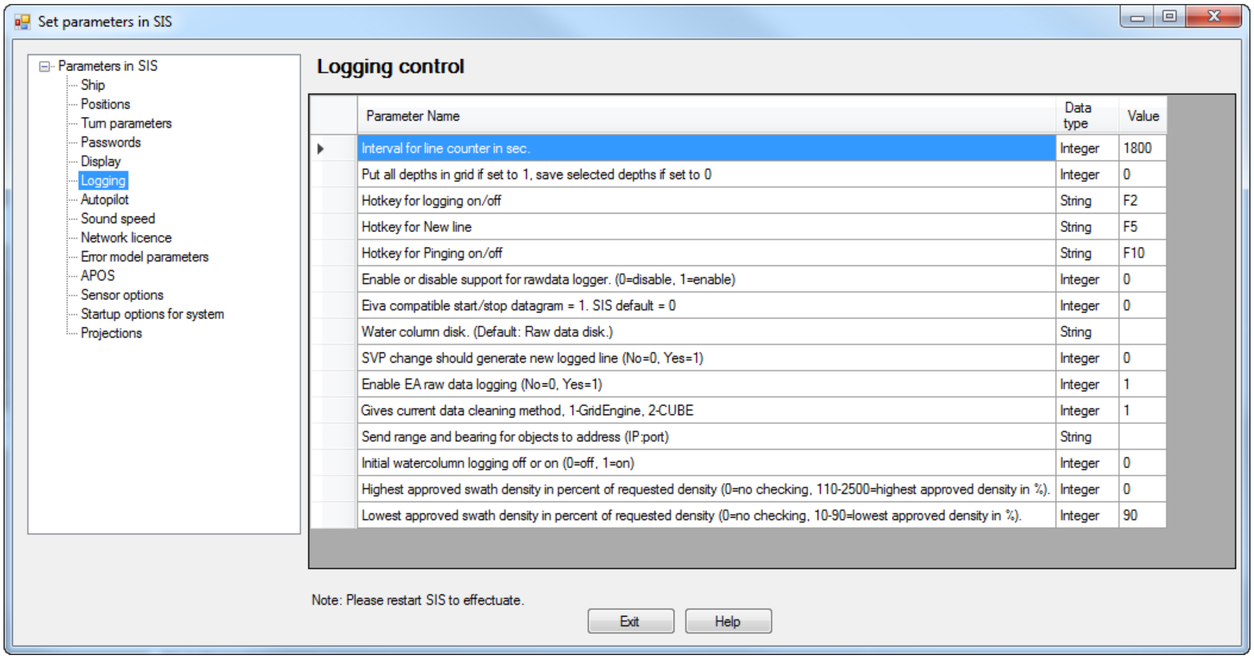

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Settings
Locations
Angular Offsets
ROV. Specific
TX Transducer Orient.
Port
Starb.
RX Transducer Orient.
Forw.
Aft
Offset angles (deg.)
Roll
Pitch
Heading
TX Transducer: -0.32704 0.26602 359.50389
RX Transducer: -0.41885 0.27675 359.49823
Attitude 1, COM2/UDP5: 0.07 -0.05 0.70
Attitude 2, COM3/UDP6: 0.00 0.00 0.00
Stand-alone Heading: 0.00

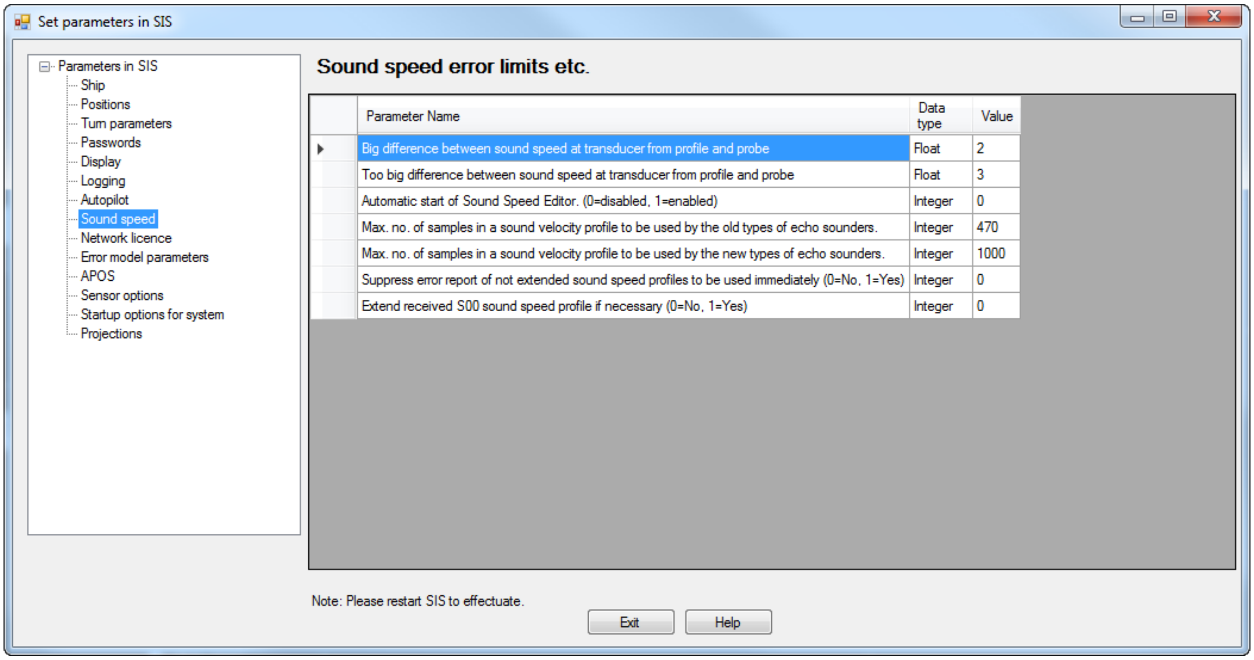

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Settings
Locations
Angular Offsets
ROV. Specific
Depth/Pressure Sensor
Delay (msec.): 0
Disable Heave Sensor

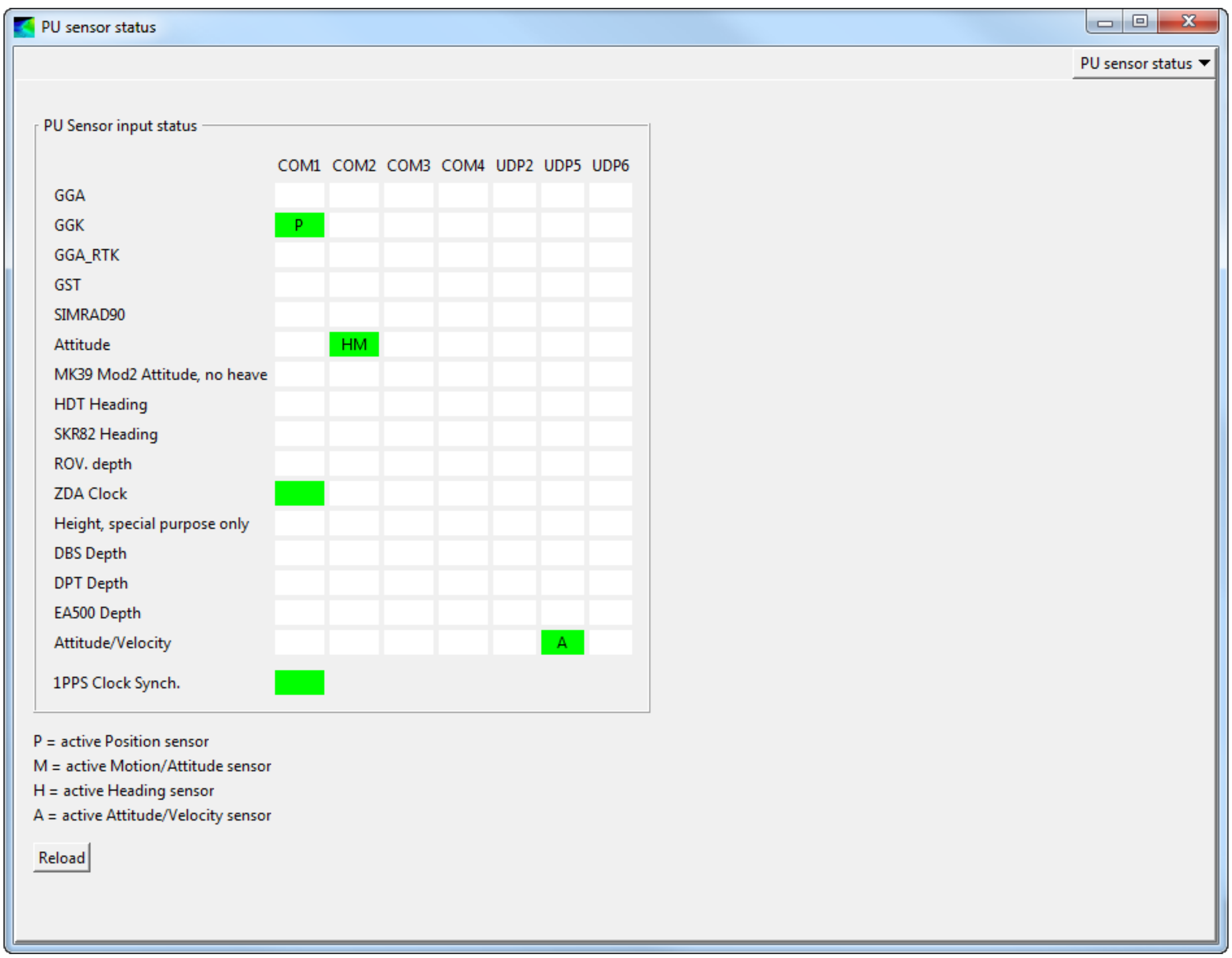

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Clear all
Run all BISTs
PU BIST Setup
0 = CPU Test
11 = RX-CPU link
2 = CBMF Test
7 = RX Channels
3 = RX unit test
8 = TX channels via RX
4 = TX unit test
9 = RX Noise Level
5 = CBMF-CPU link
10 = RX Noise Spectrum
6 = RX-CBMF link
15 = Software Date/Version
PU BIST Result
Save BIST
Date
Time
Ser. No.
BIST
Result
Description
2016.10.21
14:27:55.336
40072
11
OK
EM 2040
To be implemented
2016.10.21
14:27:55.386
40072
15
OK
PU - serial 40072:
- CPU: 2.2.0 160916
- DDS: 4.60 140106
- DSV: 3.1.8 141125
- VxWorks 6.9 SMP Build 1.09.01 Nov 23 2015 13:05:13
- CBMF: 1.11 15.01.22

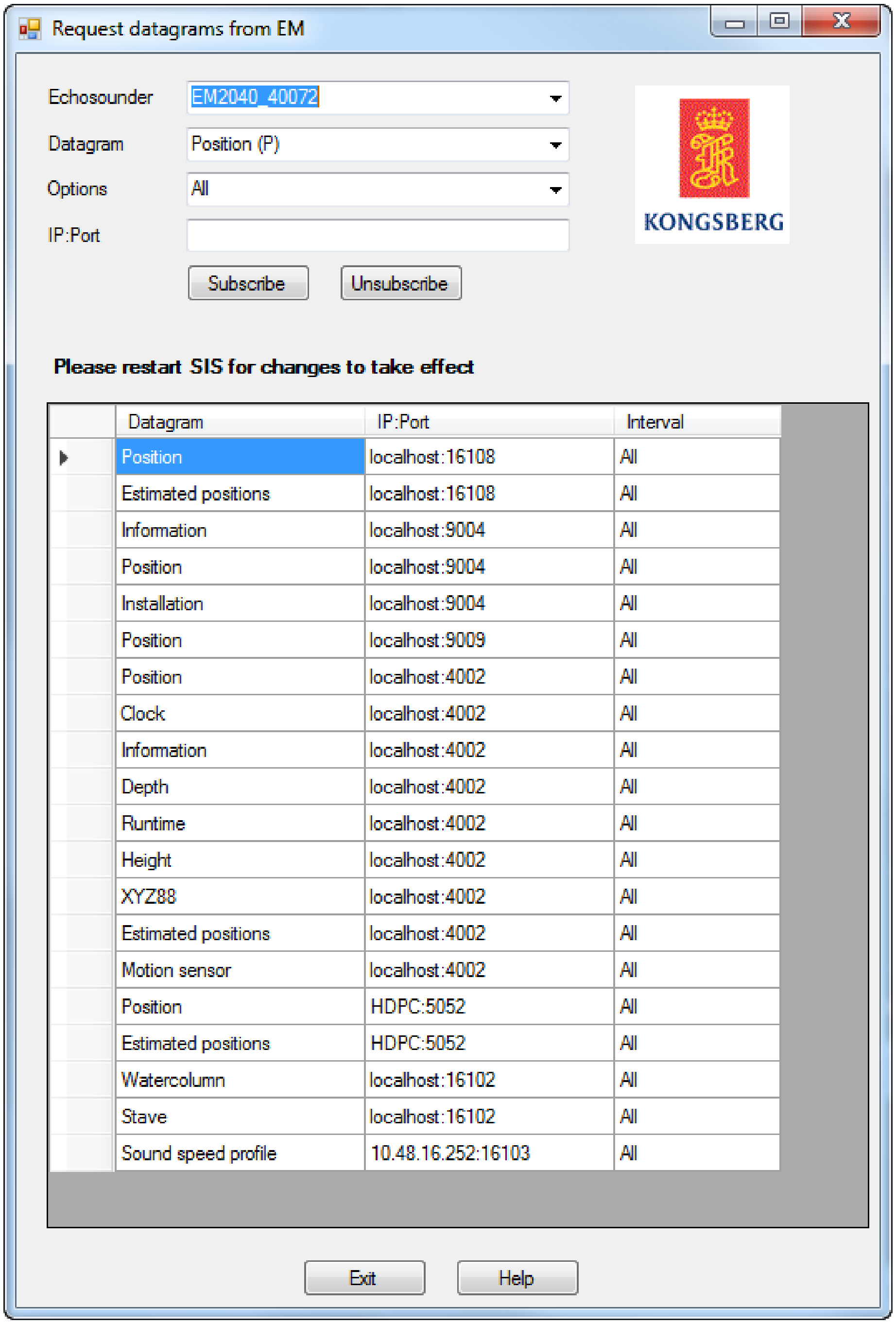

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
PU System Report
System Report.
Path:
D:\sisdata\common\bist
...
Name:

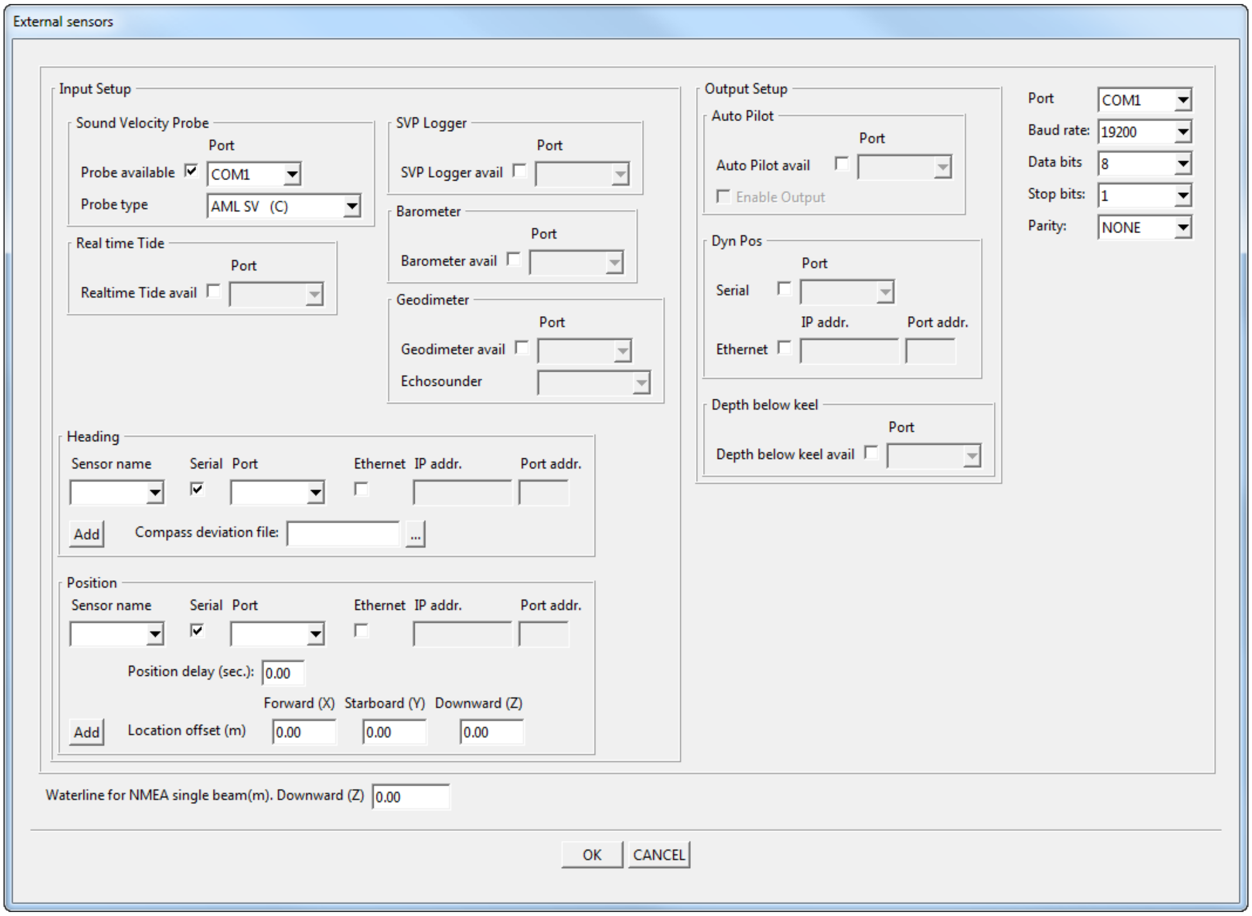

Data Distribution
Data Distribution - MDM 400
Source Port
Source File
Packets
Destination : Port
Destination : Port
Destination : Port
Destination : Port
Destination File
16103
0
10.48.16.251:6001
0
-1


Set parameters in SIS
Parameters in SIS
Ship
Positions
Turn parameters
Passwords
Display
Logging
Autopilot
Sound speed
Network licence
Error model parameters
APOS
Sensor options
Startup options for system
Projections
Logging control
Parameter Name
Data type
Value
Interval for line counter in sec.
Integer
1800
Put all depths in grid if set to 1, save selected depths if set to 0
Integer
0
Hotkey for logging on/off
String
F2
Hotkey for New line
String
F5
Hotkey for Pinging on/off
String
F10
Enable or disable support for rawdata logger. (0=disable, 1=enable)
Integer
0
Eiva compatible start/stop datagram = 1. SIS default = 0
Integer
0
Water column disk. (Default: Raw data disk.)
String
SVP change should generate new logged line (No=0, Yes=1)
Integer
0
Enable EA raw data logging (No=0, Yes=1)
Integer
1
Gives current data cleaning method, 1-GridEngine, 2-CUBE
Integer
1
Send range and bearing for objects to address (IP:port)
String
Initial watercolumn logging off or on (0=off, 1=on)
Integer
0
Highest approved swath density in percent of requested density (0=no checking, 110-2500=highest approved density in %).
Integer
0
Lowest approved swath density in percent of requested density (0=no checking, 10-90=lowest approved density in %).
Integer
90
Note: Please restart SIS to effectuate.
Exit
Help

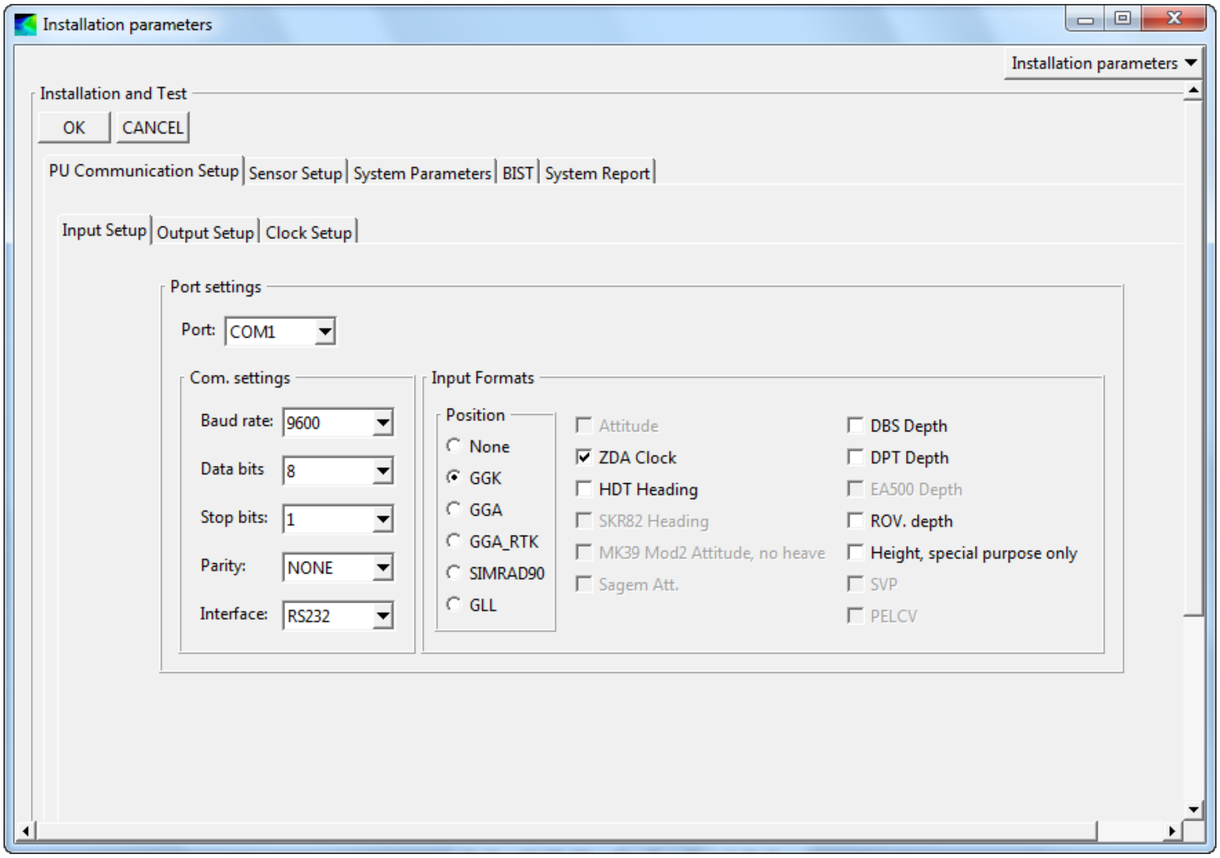

Set parameters in SIS
Parameters in SIS
Ship
Positions
Turn parameters
Passwords
Display
Logging
Autopilot
Sound speed
Network licence
Error model parameters
APOS
Sensor options
Startup options for system
Projections
Sound speed error limits etc.
Parameter Name
Data type
Value
Big difference between sound speed at transducer from profile and probe
Float
2
Too big difference between sound speed at transducer from profile and probe
Float
3
Automatic start of Sound Speed Editor. (0=disabled, 1=enabled)
Integer
0
Max. no. of samples in a sound velocity profile to be used by the old types of echo sounders.
Integer
470
Max. no. of samples in a sound velocity profile to be used by the new types of echo sounders.
Integer
1000
Suppress error report of not extended sound speed profiles to be used immediately (0=No, 1=Yes)
Integer
0
Extend received S00 sound speed profile if necessary (0=No, 1=Yes)
Integer
0
Note: Please restart SIS to effectuate.
Exit
Help

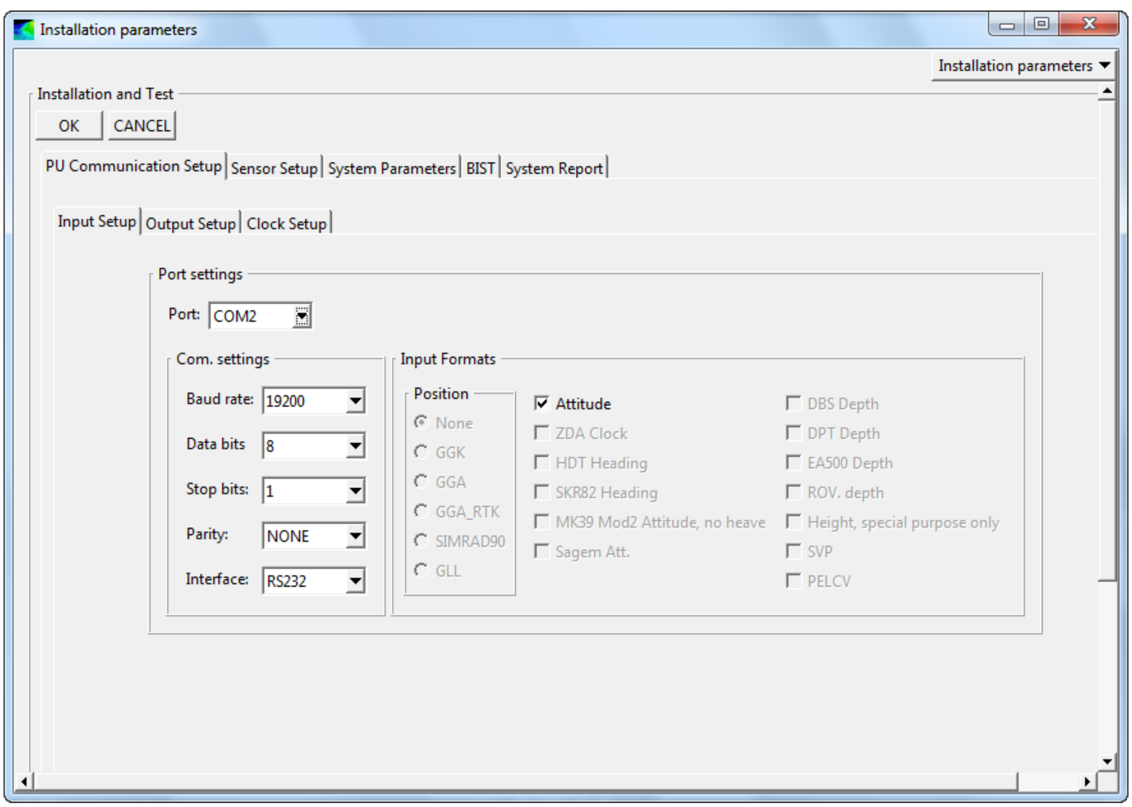

PU sensor status
PU sensor status
PU Sensor input status
COM1 COM2 COM3 COM4 UDP2 UDP5 UDP6
GGA
GGK
P
GGA_RTK
GST
SIMRAD90
Attitude
HM
MK39 Mod2 Attitude, no heave
HDT Heading
SKR82 Heading
ROV. depth
ZDA Clock
Height, special purpose only
DBS Depth
DPT Depth
EA500 Depth
Attitude/Velocity
A
1PPS Clock Synch.
P = active Position sensor
M = active Motion/Attitude sensor
H = active Heading sensor
A = active Attitude/Velocity sensor
Reload

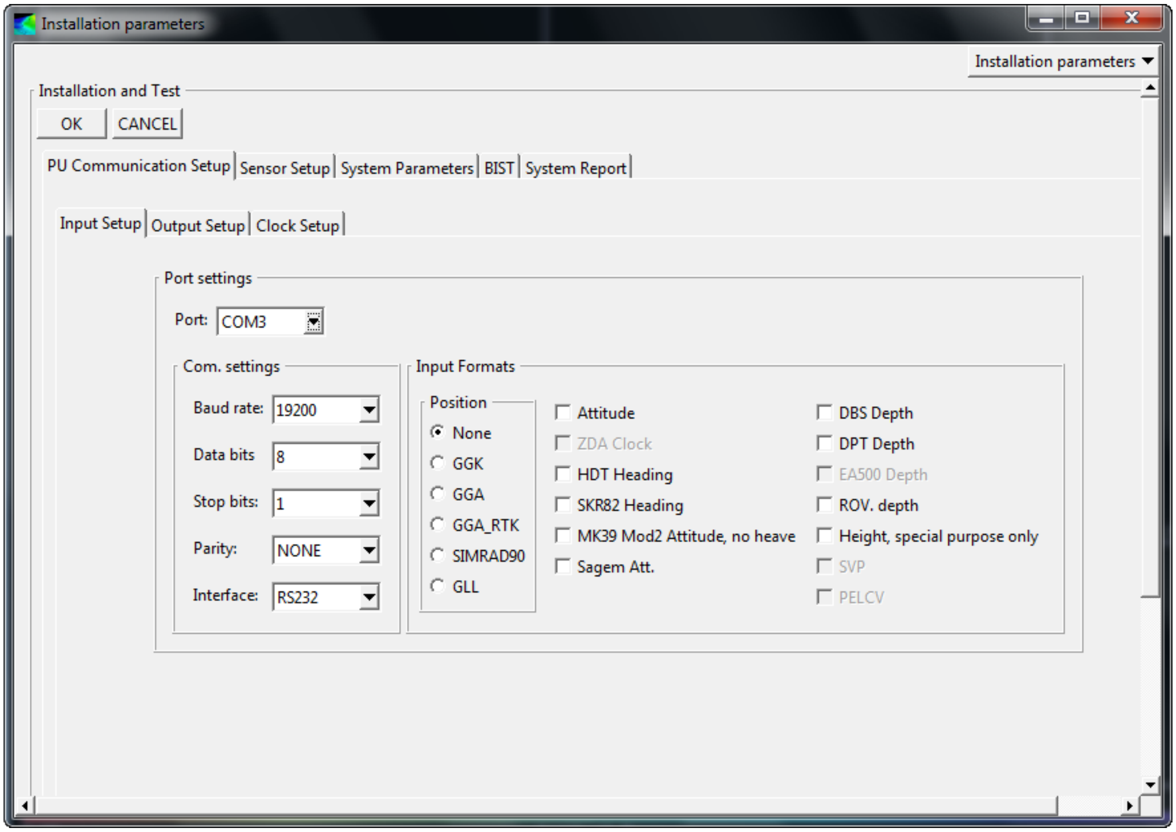

Request datagrams from EM
Echosounder
EM2040_40072
Datagram
Position (P)
Options
All
IP:Port
Subscribe
Unsubscribe
KONGSBERG
Please restart SIS for changes to take effect
Datagram
IP:Port
Interval
Position localhost:16108 All
Estimated positions localhost:16108 All
Information localhost:9004 All
Position localhost:9004 All
Installation localhost:9004 All
Position localhost:9009 All
Position localhost:4002 All
Clock localhost:4002 All
Information localhost:4002 All
Depth localhost:4002 All
Runtime localhost:4002 All
Height localhost:4002 All
XYZ88 localhost:4002 All
Estimated positions localhost:4002 All
Motion sensor localhost:4002 All
Position HDPC:5052 All
Estimated positions HDPC:5052 All
Watercolumn localhost:16102 All
Stave localhost:16102 All
Sound speed profile 10.48.16.252:16103 All
Exit
Help

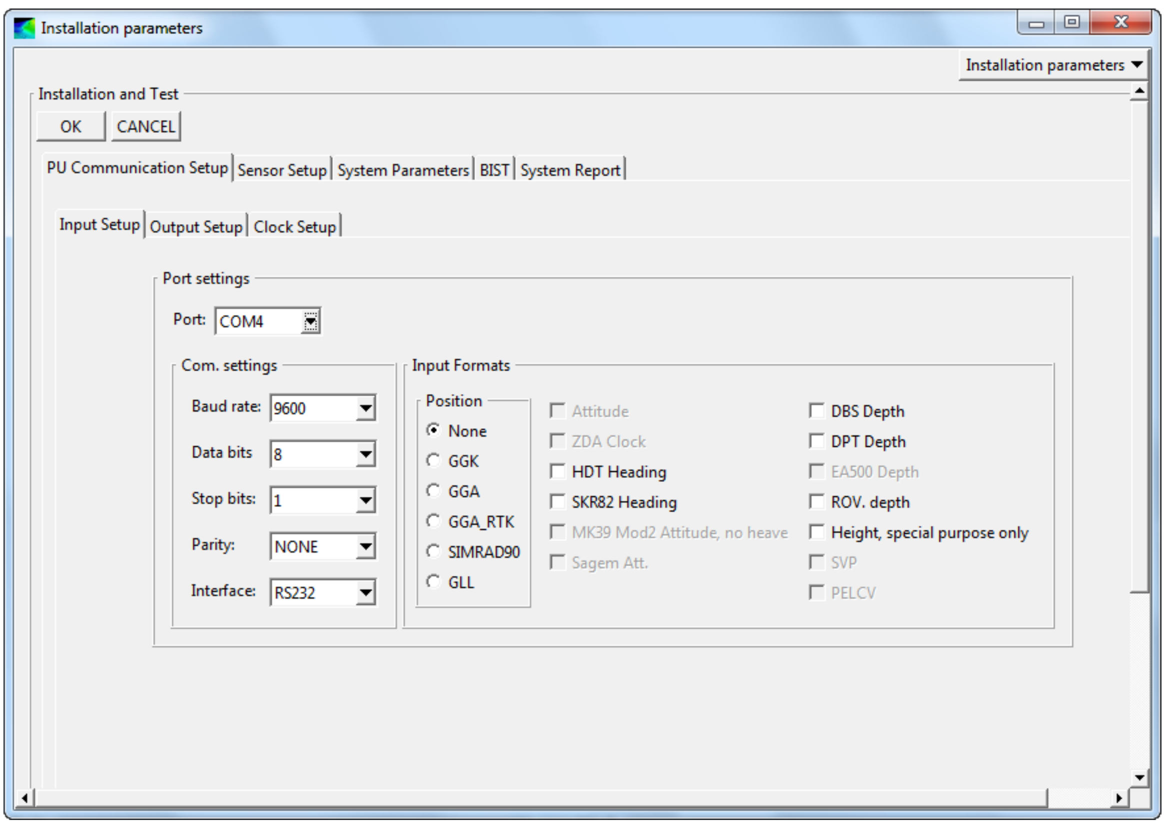

External sensors
Input Setup
Sound Velocity Probe
Port
Probe available
COM1
Probe type
AML SV (C)
SVP Logger
Port
SVP Logger avail
Barometer
Port
Barometer avail
Real time Tide
Port
Realtime Tide avail
Geodimeter
Port
Geodimeter avail
Echosounder
Heading
Sensor name
Serial
Port
Ethernet
IP addr.
Port addr.
Add
Compass deviation file:
...
Position
Sensor name
Serial
Port
Ethernet
IP addr.
Port addr.
Position delay (sec.):
0.00
Forward (X)
Starboard (Y)
Downward (Z)
Add
Location offset (m)
0.00
0.00
0.00
Output Setup
Auto Pilot
Port
Auto Pilot avail
Enable Output
Dyn Pos
Port
Serial
IP addr.
Port addr.
Ethernet
Depth below keel
Port
Depth below keel avail
Port
COM1
Baud rate:
19200
Data bits
8
Stop bits:
1
Parity:
NONE
Waterline for NMEA single beam(m). Downward (Z)
0.00
OK
CANCEL

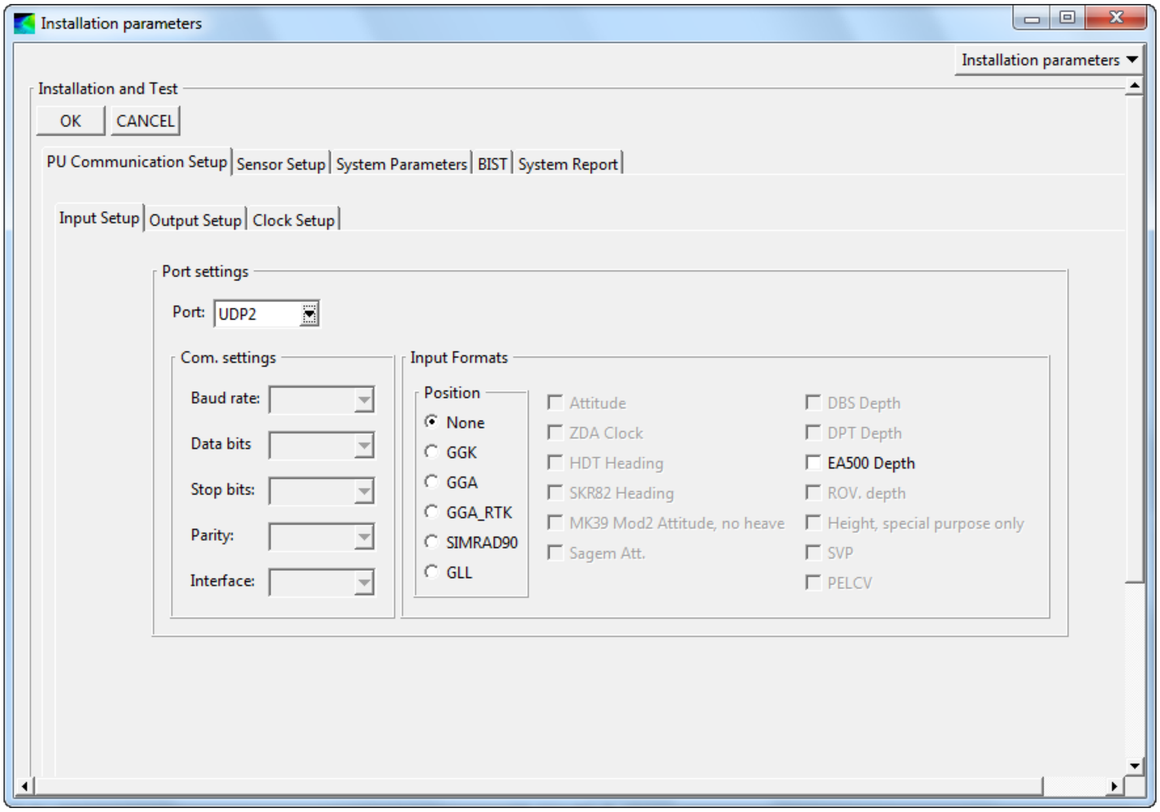
10.1.1.2 EM710

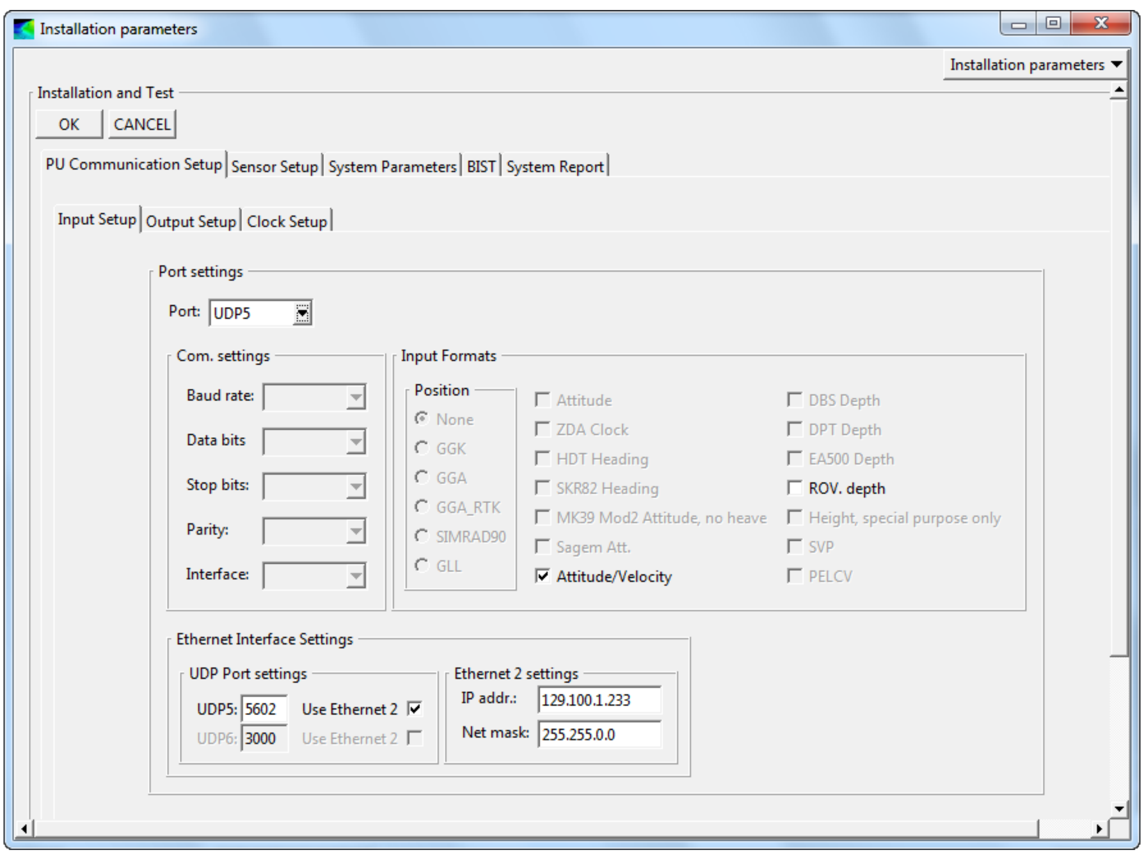

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
Port settings
Port: COM1
Com. settings
Baud rate: 9600
Data bits 8
Stop bits: 1
Parity: NONE
Interface: RS232
Input Formats
Position
None
GGK
GGA
GGA_RTK
SIMRAD90
GLL
Attitude
ZDA Clock
HDT Heading
SKR82 Heading
MK39 Mod2 Attitude, no heave
Sagem Att.
DBS Depth
DPT Depth
EA500 Depth
ROV. depth
Height, special purpose only
SVP
PELCV

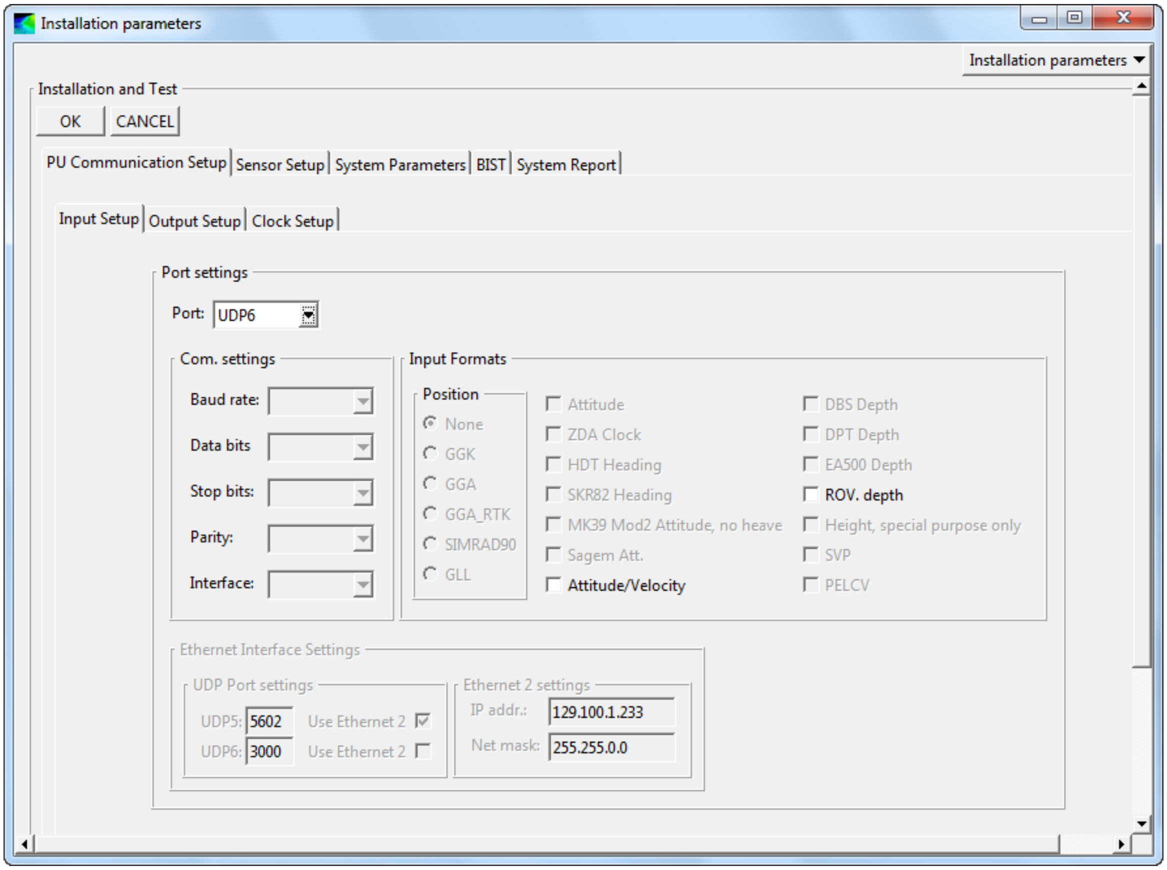

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
Port settings
Port: COM2
Com. settings
Baud rate: 19200
Data bits 8
Stop bits: 1
Parity: NONE
Interface: RS232
Input Formats
Position
None
GGK
GGA
GGA_RTK
SIMRAD90
GLL
Attitude
ZDA Clock
HDT Heading
SKR82 Heading
MK39 Mod2 Attitude, no heave
Sagem Att.
DBS Depth
DPT Depth
EA500 Depth
ROV. depth
Height, special purpose only
SVP
PELCV

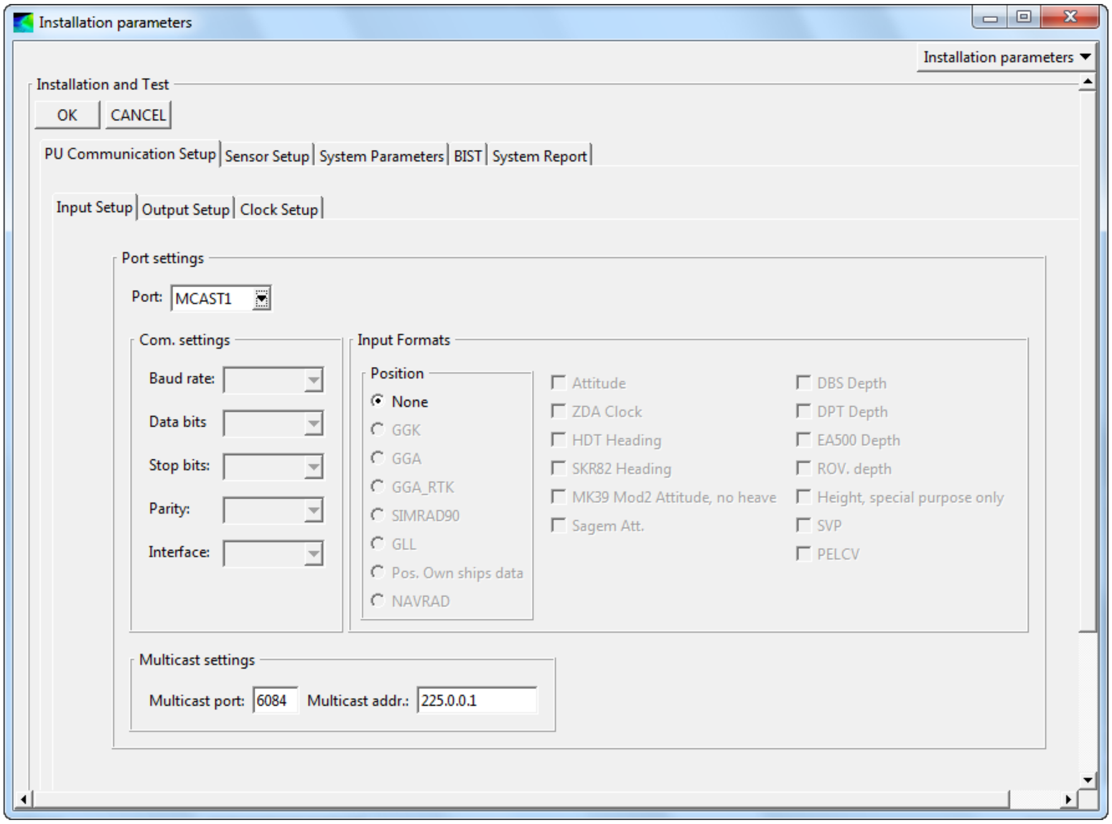

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
Port settings
Port: COM3
Com. settings
Baud rate: 19200
Data bits 8
Stop bits: 1
Parity: NONE
Interface: RS232
Input Formats
Position
None
GGK
GGA
GGA_RTK
SIMRAD90
GLL
Attitude
ZDA Clock
HDT Heading
SKR82 Heading
MK39 Mod2 Attitude, no heave
Sagem Att.
DBS Depth
DPT Depth
EA500 Depth
ROV. depth
Height, special purpose only
SVP
PELCV

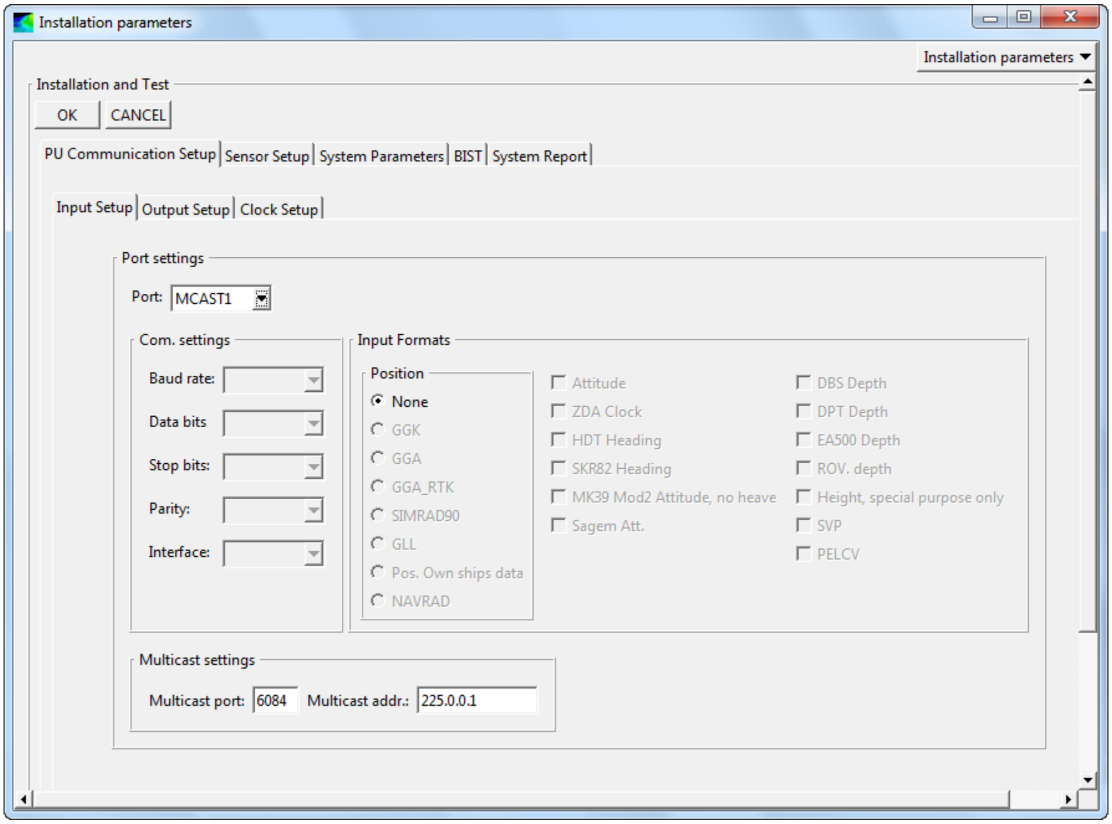

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
Port settings
Port: COM4
Com. settings
Baud rate: 9600
Data bits 8
Stop bits: 1
Parity: NONE
Interface: RS232
Input Formats
Position
None
GGK
GGA
GGA_RTK
SIMRAD90
GLL
Attitude
ZDA Clock
HDT Heading
SKR82 Heading
MK39 Mod2 Attitude, no heave
Sagem Att.
DBS Depth
DPT Depth
EA500 Depth
ROV. depth
Height, special purpose only
SVP
PELCV

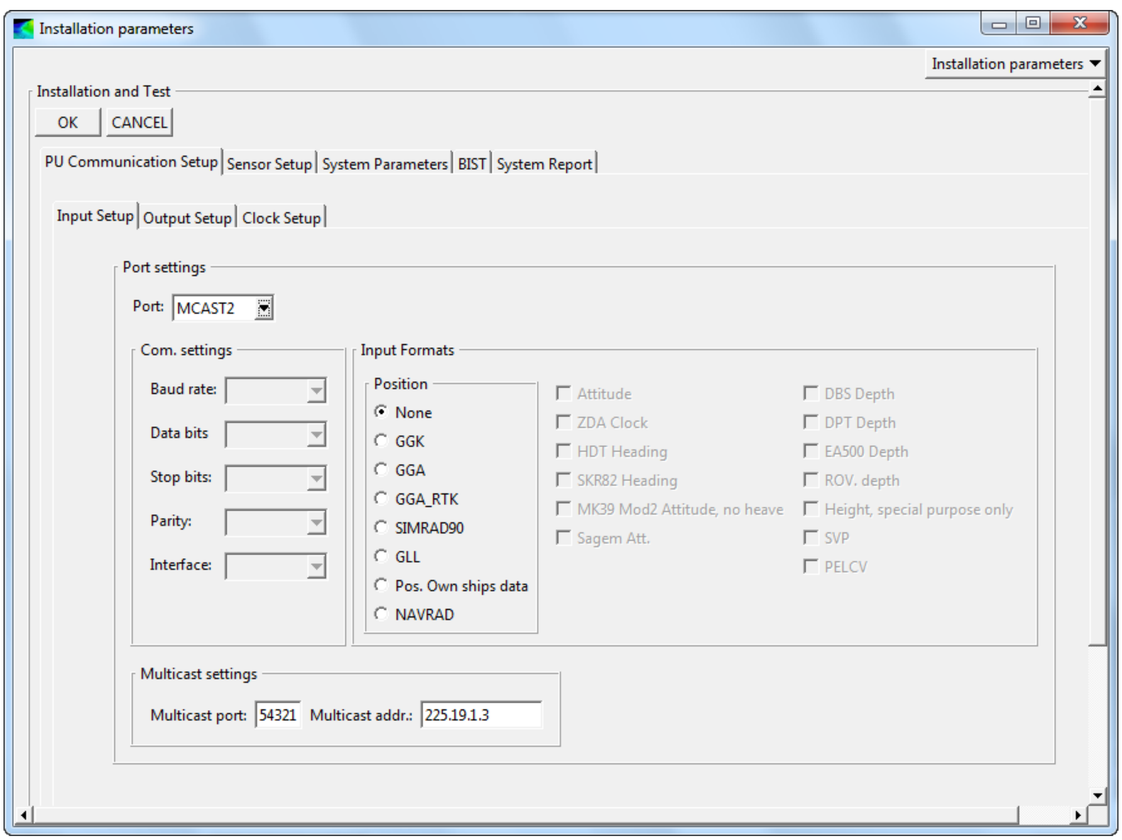

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
Port settings
Port:
UDP2
Com. settings
Baud rate:
Data bits
Stop bits:
Parity:
Interface:
Input Formats
Position
None
GGK
GGA
GGA_RTK
SIMRAD90
GLL
Attitude
ZDA Clock
HDT Heading
SKR82 Heading
MK39 Mod2 Attitude, no heave
Sagem Att.
DBS Depth
DPT Depth
EA500 Depth
ROV. depth
Height, special purpose only
SVP
PELCV

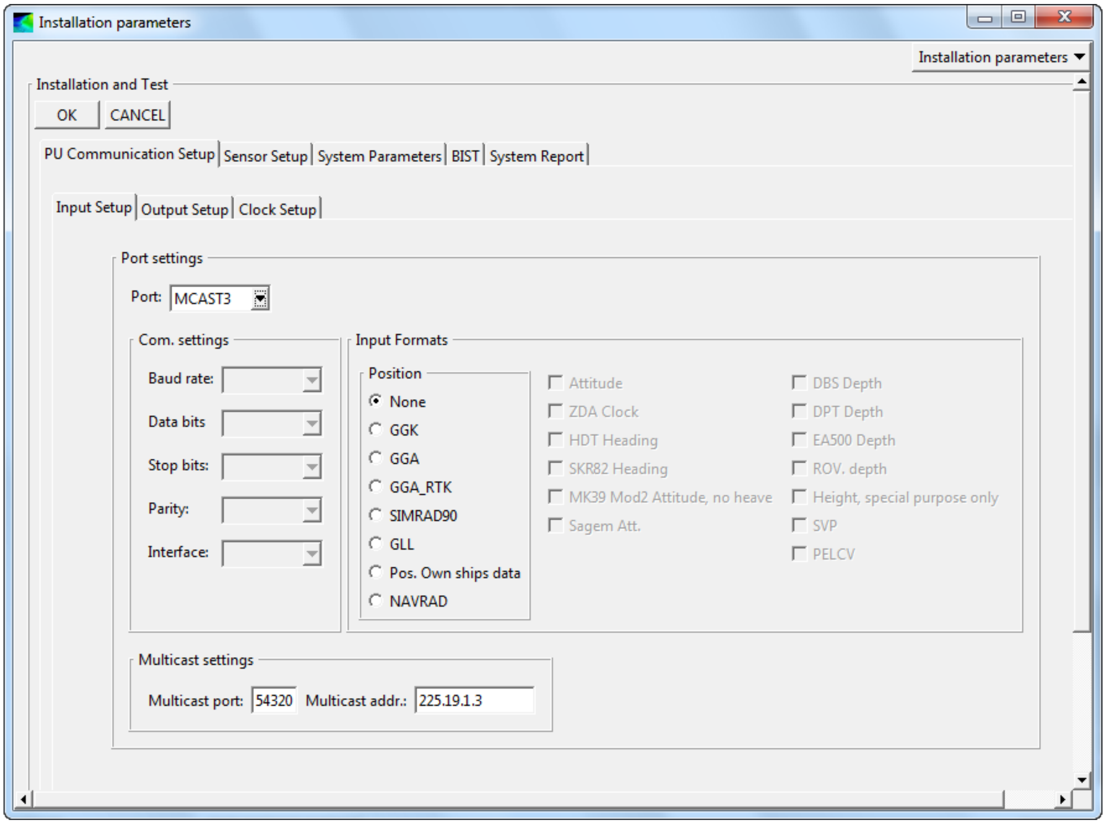

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
Port settings
Port:
UDP5
Com. settings
Baud rate:
Data bits
Stop bits:
Parity:
Interface:
Input Formats
Position
None
GGK
GGA
GGA_RTK
SIMRAD90
GLL
Attitude
ZDA Clock
HDT Heading
SKR82 Heading
MK39 Mod2 Attitude, no heave
Sagem Att.
Attitude/Velocity
DBS Depth
DPT Depth
EA500 Depth
ROV. depth
Height, special purpose only
SVP
PELCV
Ethernet Interface Settings
UDP Port settings
UDP5: 5602
Use Ethernet 2
UDP6: 3000
Use Ethernet 2
Ethernet 2 settings
IP addr.: 129.100.1.233
Net mask: 255.255.0.0

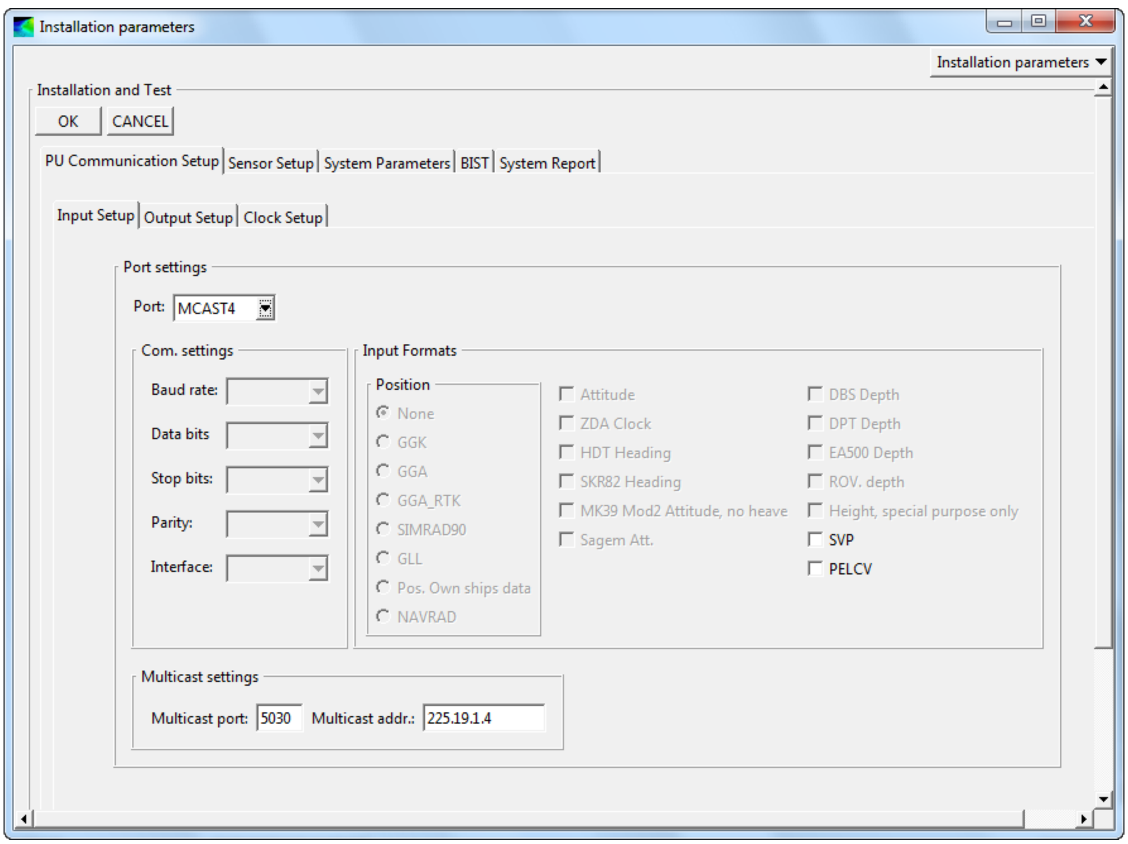

Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
Port settings
Port: UDP6
Com. settings
Baud rate:
Data bits
Stop bits:
Parity:
Interface:
Input Formats
Position
None
GGK
GGA
GGA_RTK
SIMRAD90
GLL
Attitude
ZDA Clock
HDT Heading
SKR82 Heading
MK39 Mod2 Attitude, no heave
Sagem Att.
Attitude/Velocity
DBS Depth
DPT Depth
EA500 Depth
ROV. depth
Height, special purpose only
SVP
PELCV
Ethernet Interface Settings
UDP Port settings
UDP5: 5602 Use Ethernet 2
UDP6: 3000 Use Ethernet 2
Ethernet 2 settings
IP addr.: 129.100.1.233
Net mask: 255.255.0.0

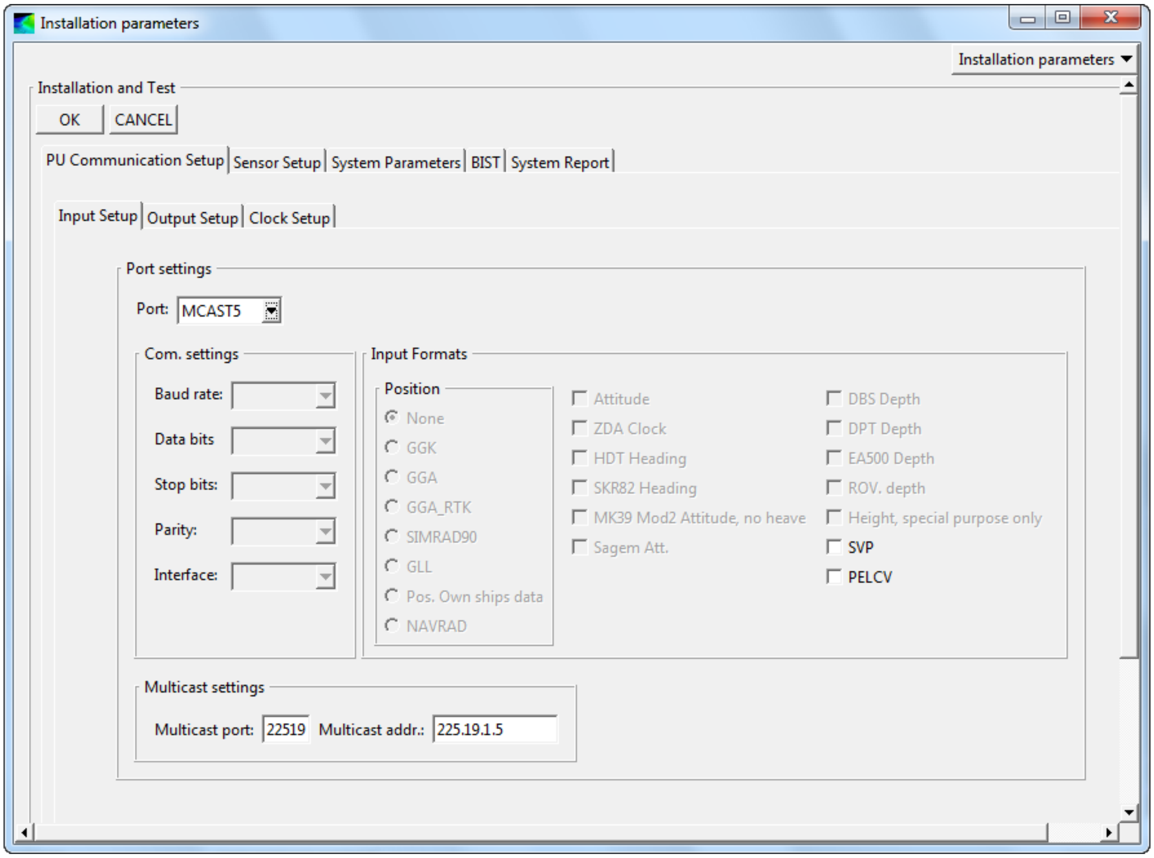

Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
Port settings
Port: MCAST1
Com. settings
Baud rate:
Data bits
Stop bits:
Parity:
Interface:
Input Formats
Position
None
GGK
GGA
GGA_RTK
SIMRAD90
GLL
Pos. Own ships data
NAVRAD
Attitude
ZDA Clock
HDT Heading
SKR82 Heading
MK39 Mod2 Attitude, no heave
Sagem Att.
DBS Depth
DPT Depth
EA500 Depth
ROV. depth
Height, special purpose only
SVP
PELCV
Multicast settings
Multicast port: 6084 Multicast addr.: 225.0.0.1

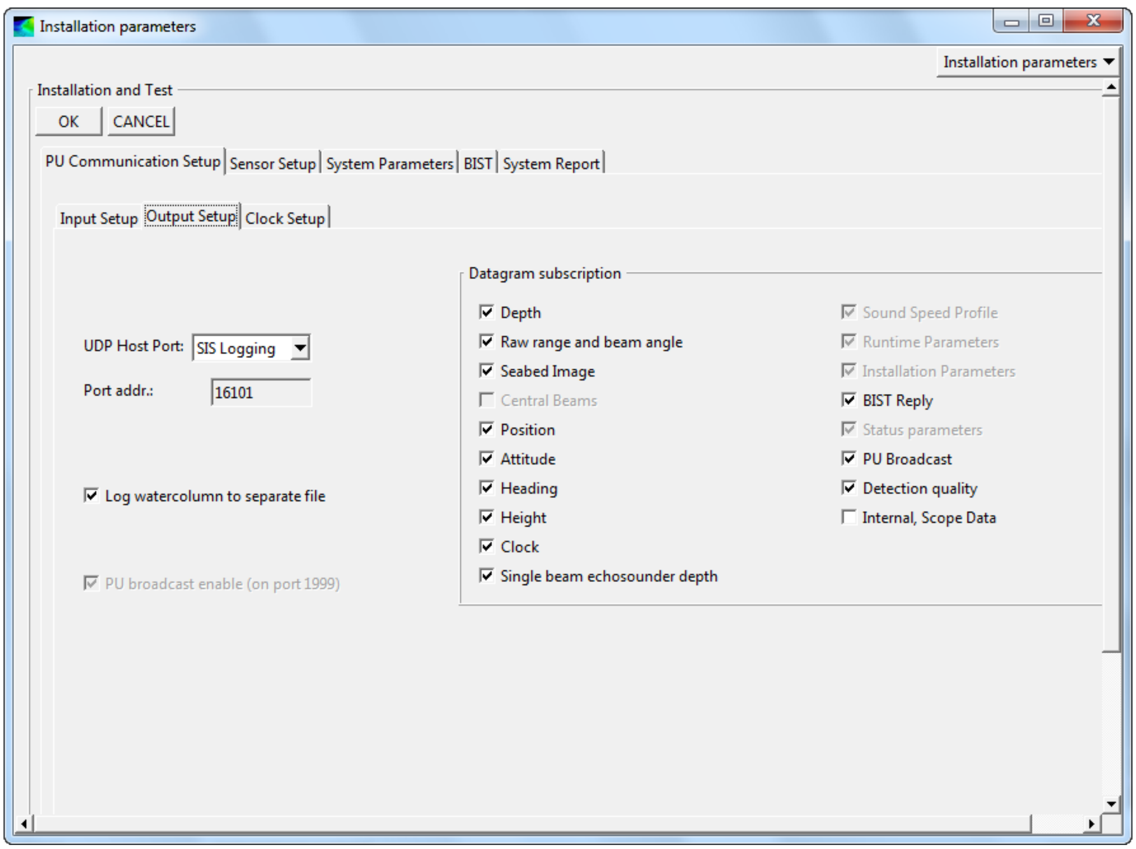

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
Port settings
Port:
MCAST1
Com. settings
Baud rate:
Data bits
Stop bits:
Parity:
Interface:
Input Formats
Position
None
GGK
GGA
GGA_RTK
SIMRAD90
GLL
Pos. Own ships data
NAVRAD
Attitude
ZDA Clock
HDT Heading
SKR82 Heading
MK39 Mod2 Attitude, no heave
Sagem Att.
DBS Depth
DPT Depth
EA500 Depth
ROV. depth
Height, special purpose only
SVP
PELCV
Multicast settings
Multicast port:
6084
Multicast addr.:
225.0.0.1

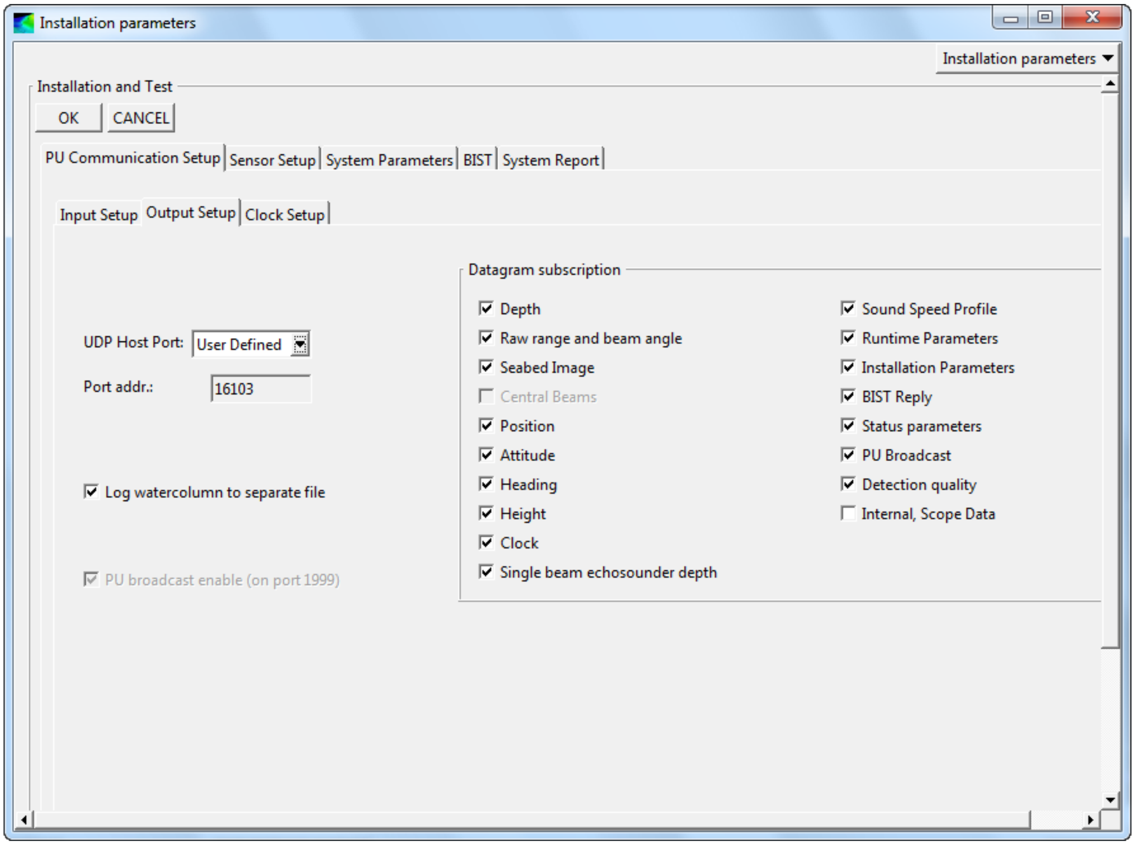

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
Port settings
Port:
MCAST2
Com. settings
Baud rate:
Data bits
Stop bits:
Parity:
Interface:
Input Formats
Position
None
GGK
GGA
GGA_RTK
SIMRAD90
GLL
Pos. Own ships data
NAVRAD
Attitude
ZDA Clock
HDT Heading
SKR82 Heading
MK39 Mod2 Attitude, no heave
Sagem Att.
DBS Depth
DPT Depth
EA500 Depth
ROV. depth
Height, special purpose only
SVP
PELCV
Multicast settings
Multicast port:
54321
Multicast addr.:
225.19.1.3


Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
Port settings
Port: MCAST3
Com. settings
Baud rate:
Data bits
Stop bits:
Parity:
Interface:
Input Formats
Position
None
GGK
GGA
GGA_RTK
SIMRAD90
GLL
Pos. Own ships data
NAVRAD
Attitude
ZDA Clock
HDT Heading
SKR82 Heading
MK39 Mod2 Attitude, no heave
Sagem Att.
DBS Depth
DPT Depth
EA500 Depth
ROV. depth
Height, special purpose only
SVP
PELCV
Multicast settings
Multicast port: 54320
Multicast addr.: 225.19.1.3

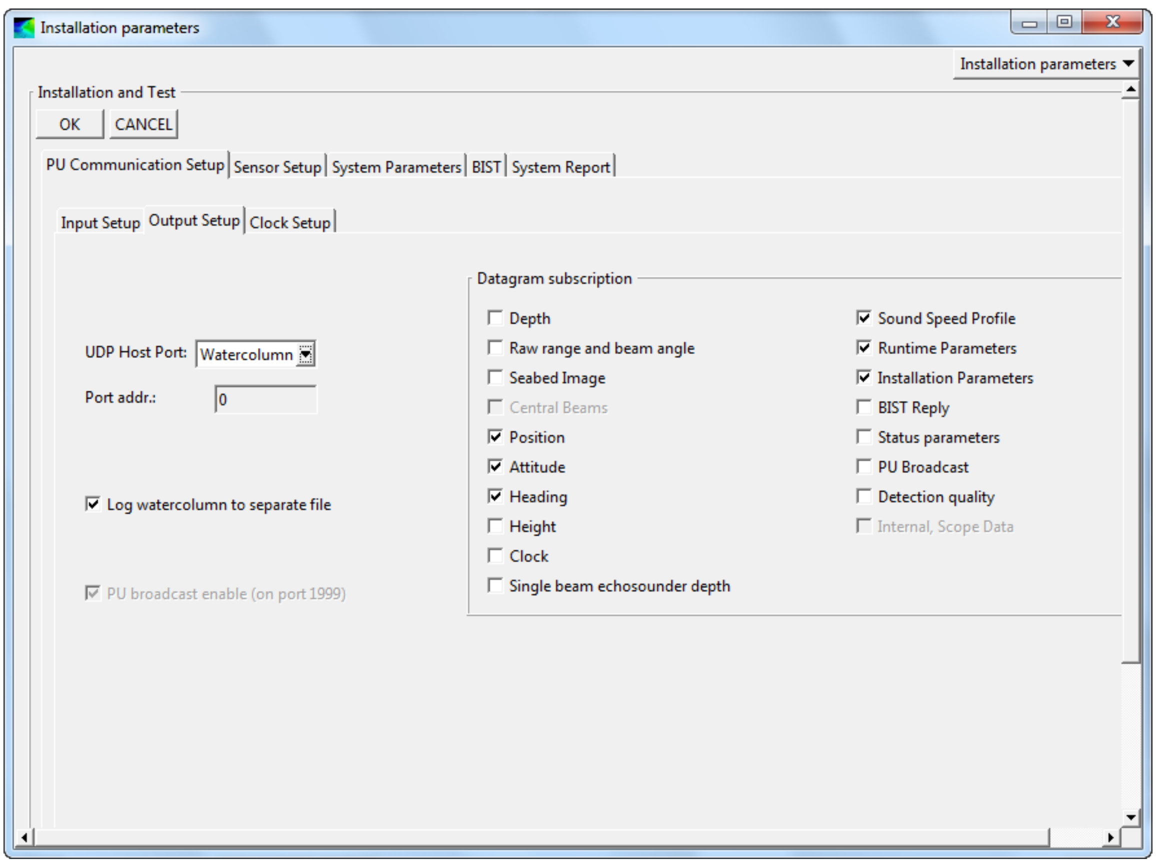

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
Port settings
Port: MCAST4
Com. settings
Baud rate:
Data bits
Stop bits:
Parity:
Interface:
Input Formats
Position
None
GGK
GGA
GGA_RTK
SIMRAD90
GLL
Pos. Own ships data
NAVRAD
Attitude
ZDA Clock
HDT Heading
SKR82 Heading
MK39 Mod2 Attitude, no heave
Sagem Att.
DBS Depth
DPT Depth
EA500 Depth
ROV. depth
Height, special purpose only
SVP
PELCV
Multicast settings
Multicast port: 5030
Multicast addr.: 225.19.1.4


Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
Port settings
Port: MCAST5
Com. settings
Baud rate:
Data bits
Stop bits:
Parity:
Interface:
Input Formats
Position
None
GGK
GGA
GGA_RTK
SIMRAD90
GLL
Pos. Own ships data
NAVRAD
Attitude
ZDA Clock
HDT Heading
SKR82 Heading
MK39 Mod2 Attitude, no heave
Sagem Att.
DBS Depth
DPT Depth
EA500 Depth
ROV. depth
Height, special purpose only
SVP
PELCV
Multicast settings
Multicast port: 22519
Multicast addr.: 225.19.1.5

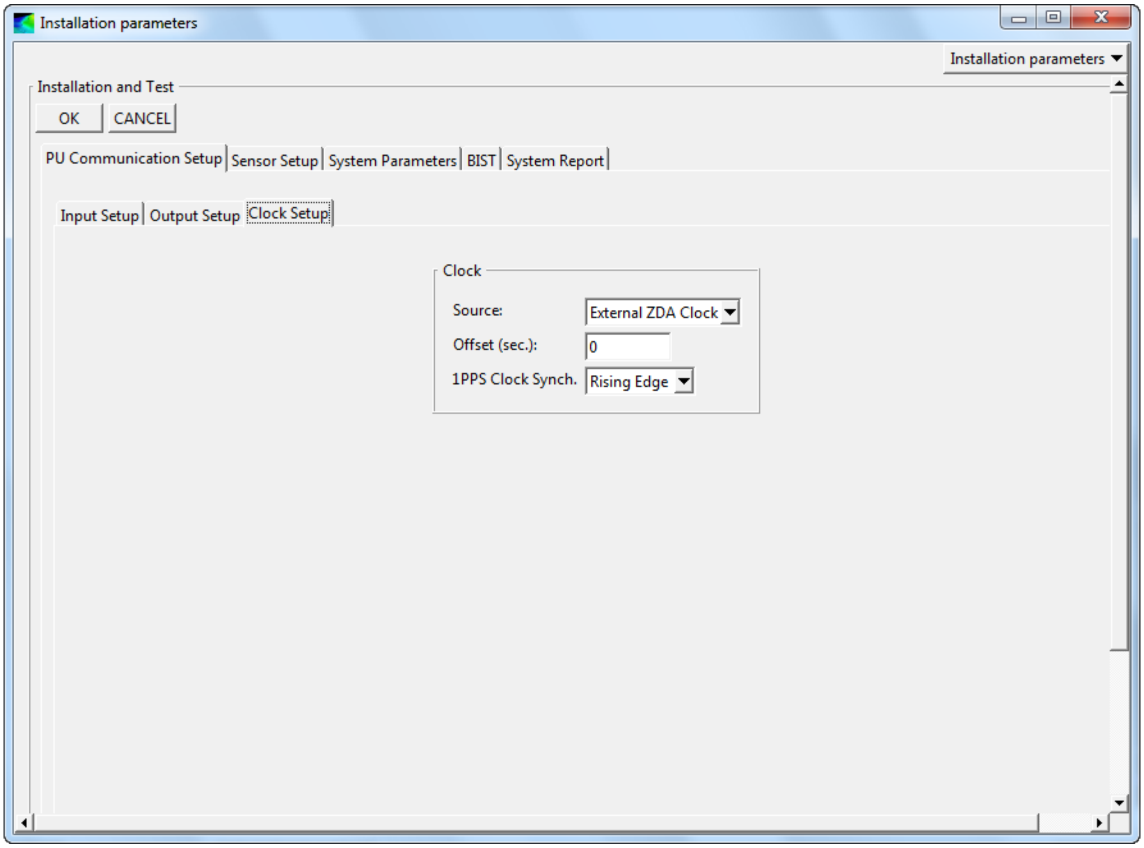

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
UDP Host Port: SIS Logging
Port addr.: 16101
Log watercolumn to separate file
PU broadcast enable (on port 1999)
Datagram subscription
Depth
Raw range and beam angle
Seabed Image
Central Beams
Position
Attitude
Heading
Height
Clock
Single beam echosounder depth
Sound Speed Profile
Runtime Parameters
Installation Parameters
BIST Reply
Status parameters
PU Broadcast
Detection quality
Internal, Scope Data

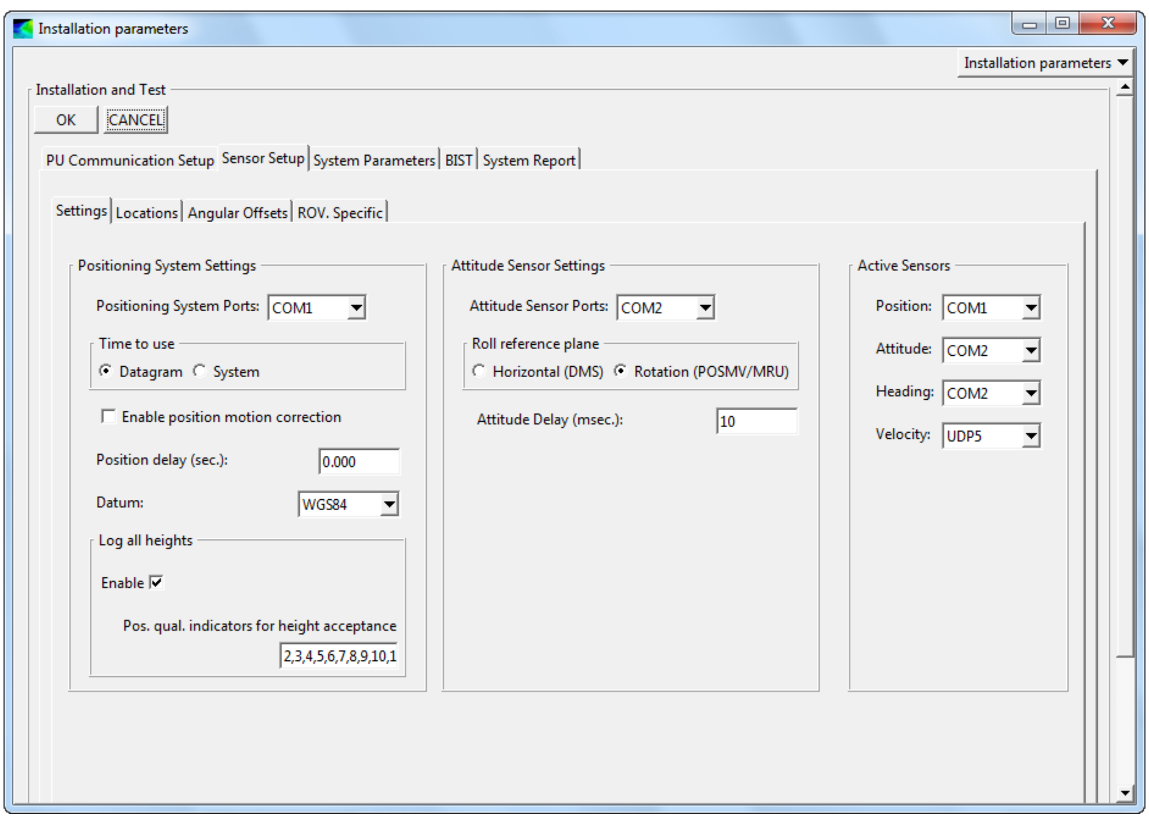


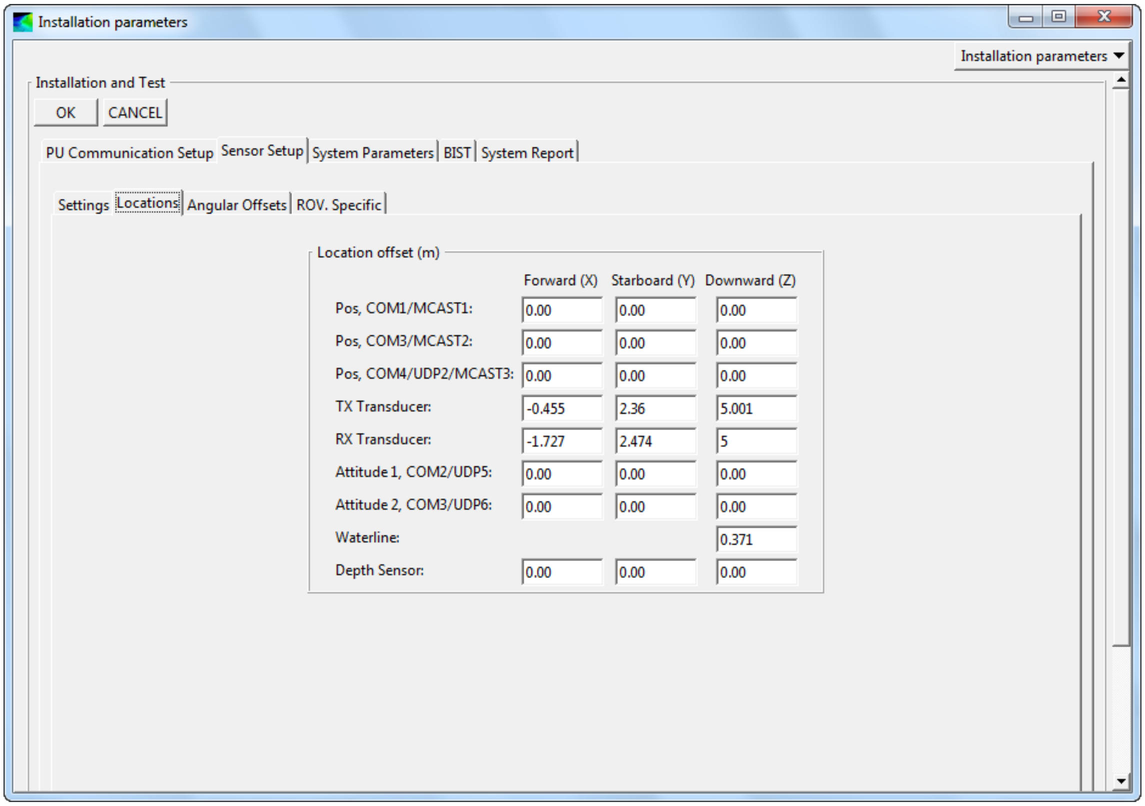
Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
Datagram subscription
UDP Host Port:
User Defined
Port addr.:
16103
Log watercolumn to separate file
PU broadcast enable (on port 1999)
Depth
Raw range and beam angle
Seabed Image
Central Beams
Position
Attitude
Heading
Height
Clock
Single beam echosounder depth
Sound Speed Profile
Runtime Parameters
Installation Parameters
BIST Reply
Status parameters
PU Broadcast
Detection quality
Internal, Scope Data

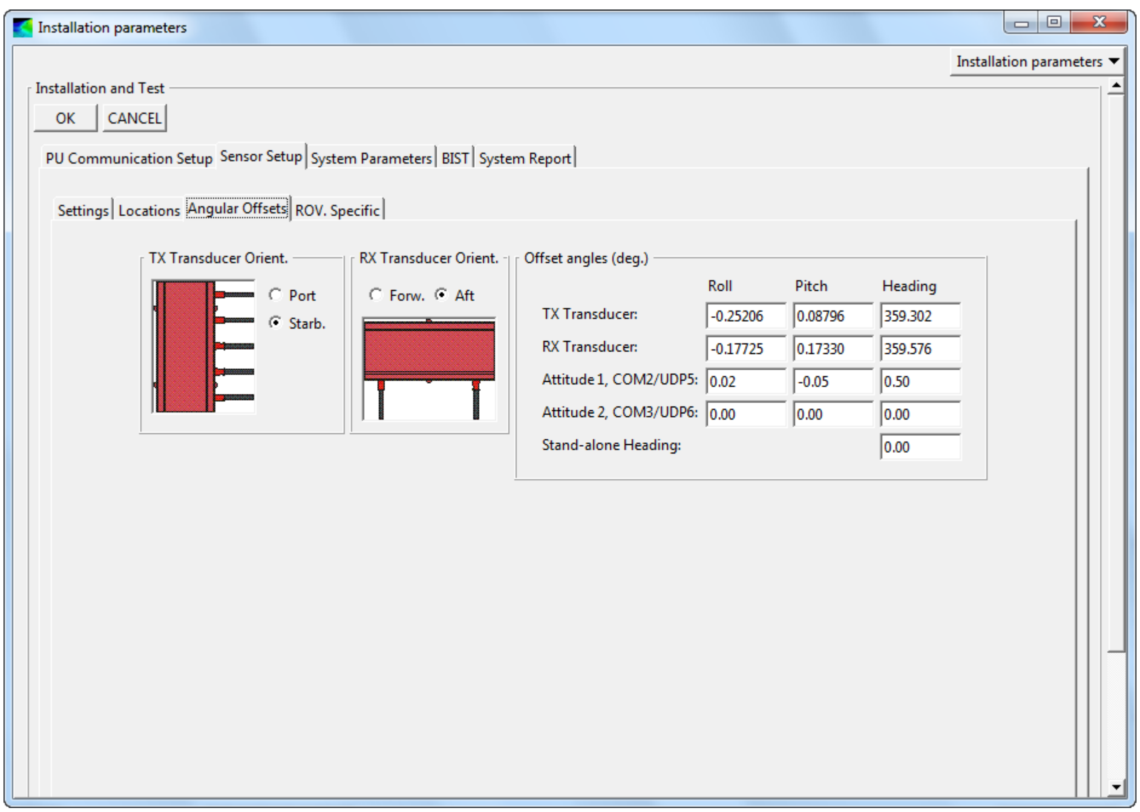


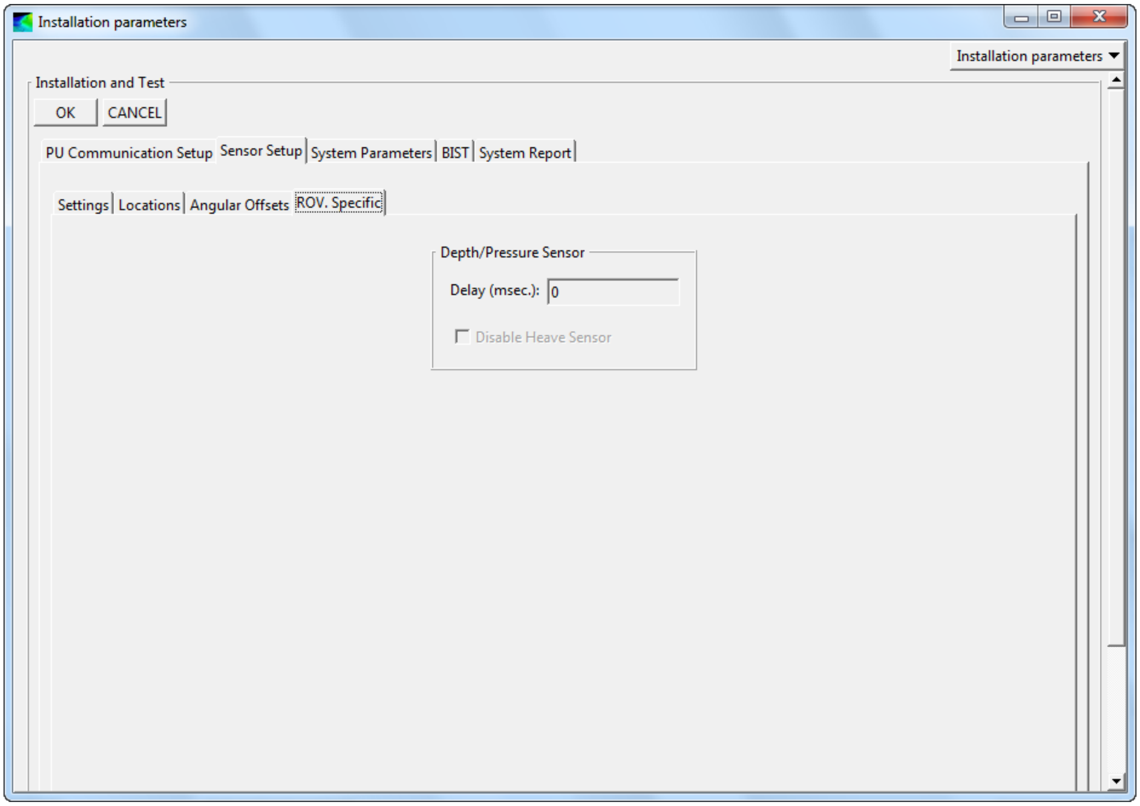
Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
Datagram subscription
UDP Host Port:
Watercolumn
Port addr.:
0
Log watercolumn to separate file
PU broadcast enable (on port 1999)
Depth
Raw range and beam angle
Seabed Image
Central Beams
Position
Attitude
Heading
Height
Clock
Single beam echosounder depth
Sound Speed Profile
Runtime Parameters
Installation Parameters
BIST Reply
Status parameters
PU Broadcast
Detection quality
Internal, Scope Data

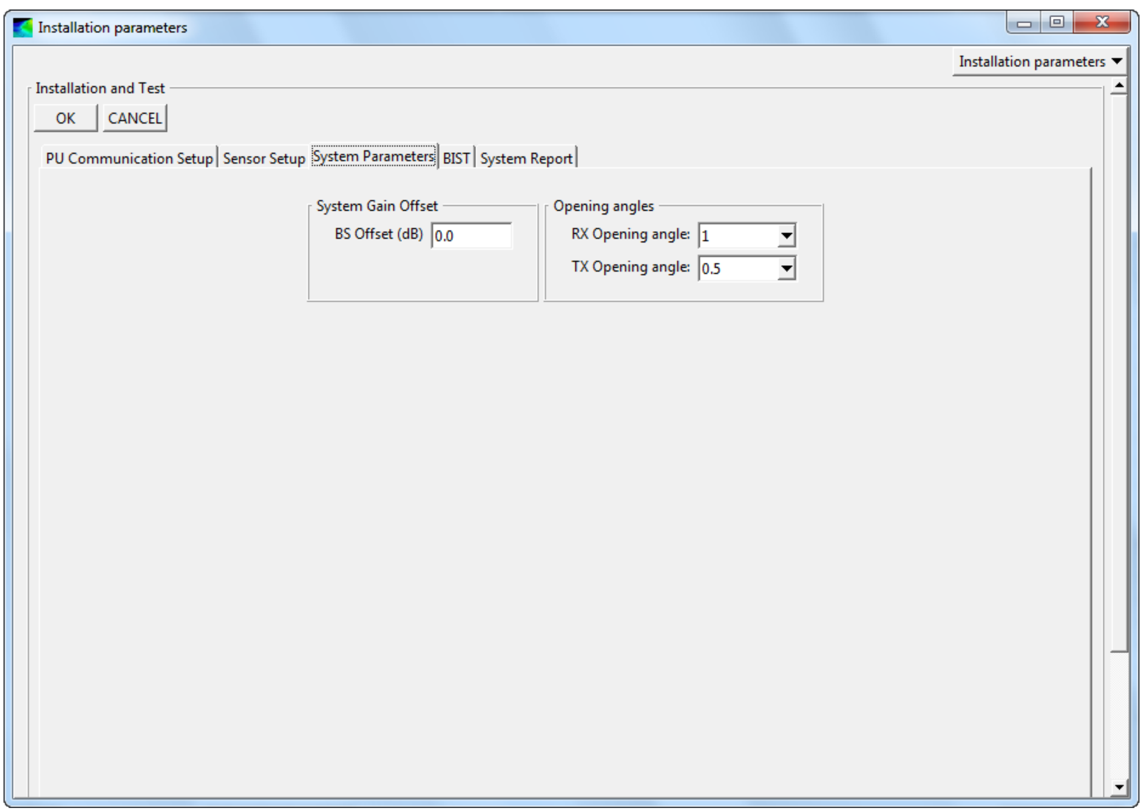

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
Clock
Source:
External ZDA Clock
Offset (sec.):
0
1PPS Clock Synch.
Rising Edge

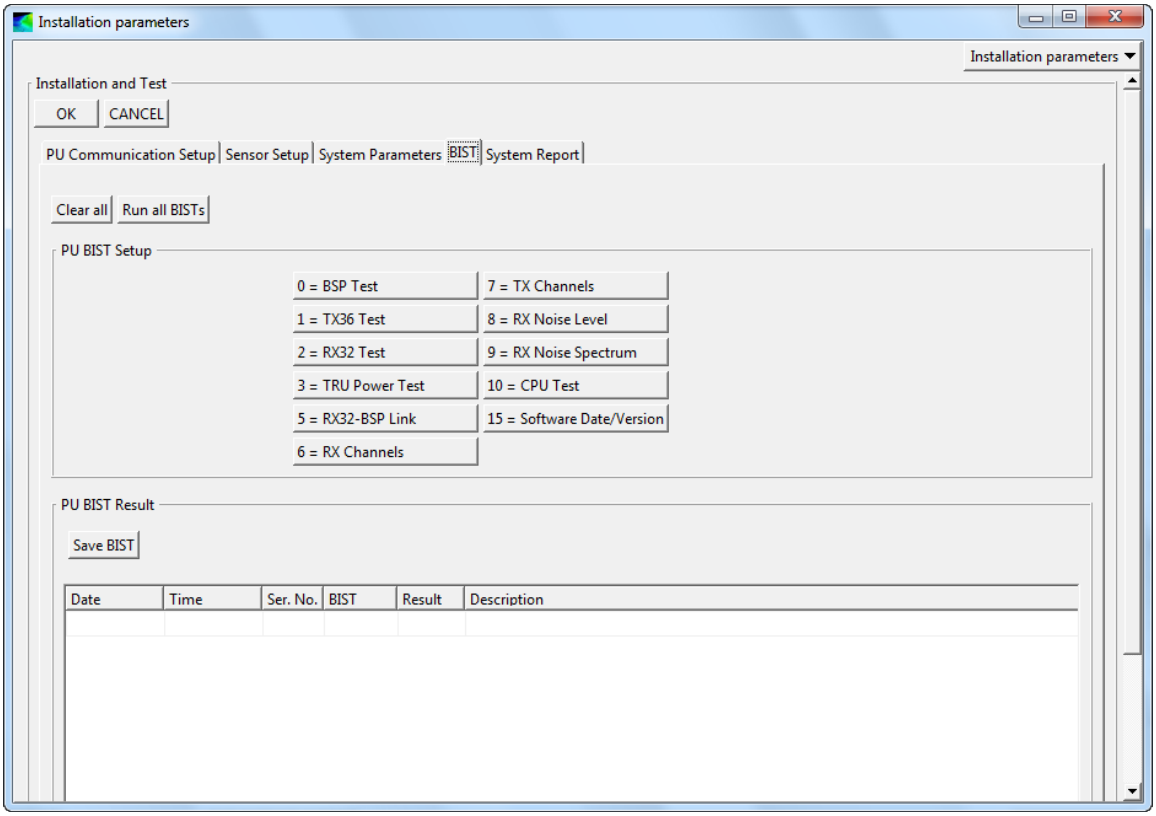

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Settings
Locations
Angular Offsets
ROV. Specific
Positioning System Settings
Positioning System Ports:
COM1
Time to use
Datagram
System
Enable position motion correction
Position delay (sec.):
0.000
Datum:
WGS84
Log all heights
Enable
Pos. qual. indicators for height acceptance
2,3,4,5,6,7,8,9,10,1
Attitude Sensor Settings
Attitude Sensor Ports:
COM2
Roll reference plane
Horizontal (DMS)
Rotation (POSMV/MRU)
Attitude Delay (msec.):
10
Active Sensors
Position:
COM1
Attitude:
COM2
Heading:
COM2
Velocity:
UDP5

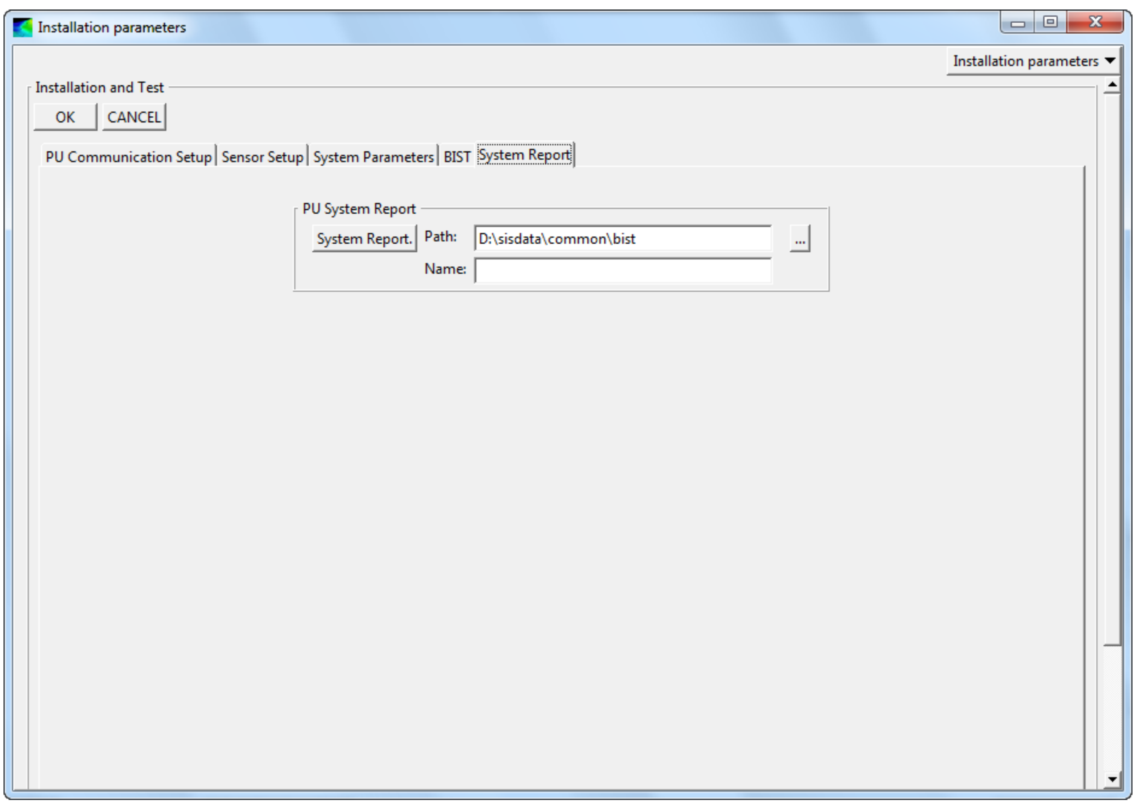

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Settings
Locations
Angular Offsets
ROV. Specific
Location offset (m)
Forward (X)
Starboard (Y)
Downward (Z)
Pos, COM1/MCAST1: 0.00 0.00 0.00
Pos, COM3/MCAST2: 0.00 0.00 0.00
Pos, COM4/UDP2/MCAST3: 0.00 0.00 0.00
TX Transducer: -0.455 2.36 5.001
RX Transducer: -1.727 2.474 5
Attitude 1, COM2/UDP5: 0.00 0.00 0.00
Attitude 2, COM3/UDP6: 0.00 0.00 0.00
Waterline: 0.371
Depth Sensor: 0.00 0.00 0.00

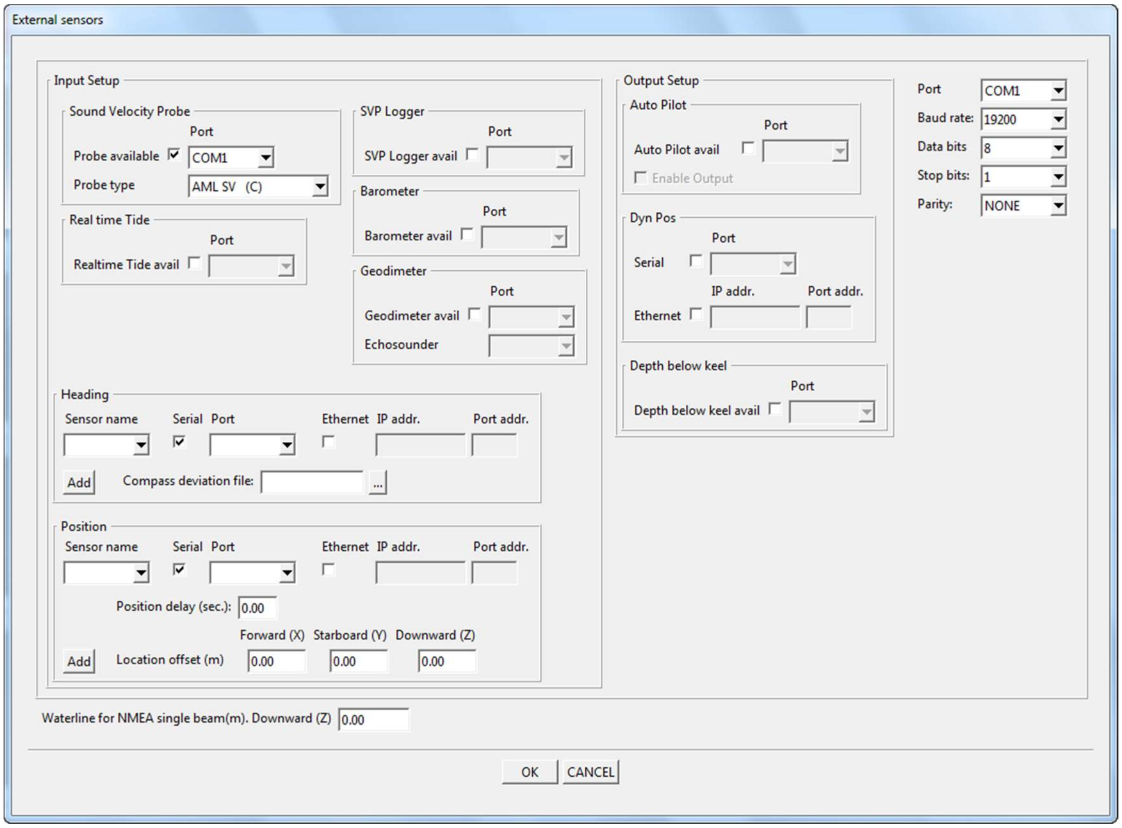

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Settings
Locations
Angular Offsets
ROV. Specific
TX Transducer Orient.
Port
Starb.
RX Transducer Orient.
Forw.
Aft
Offset angles (deg.)
Roll
Pitch
Heading
TX Transducer: -0.25206 0.08796 359.302
RX Transducer: -0.17725 0.17330 359.576
Attitude 1, COM2/UDP5: 0.02 -0.05 0.50
Attitude 2, COM3/UDP6: 0.00 0.00 0.00
Stand-alone Heading: 0.00

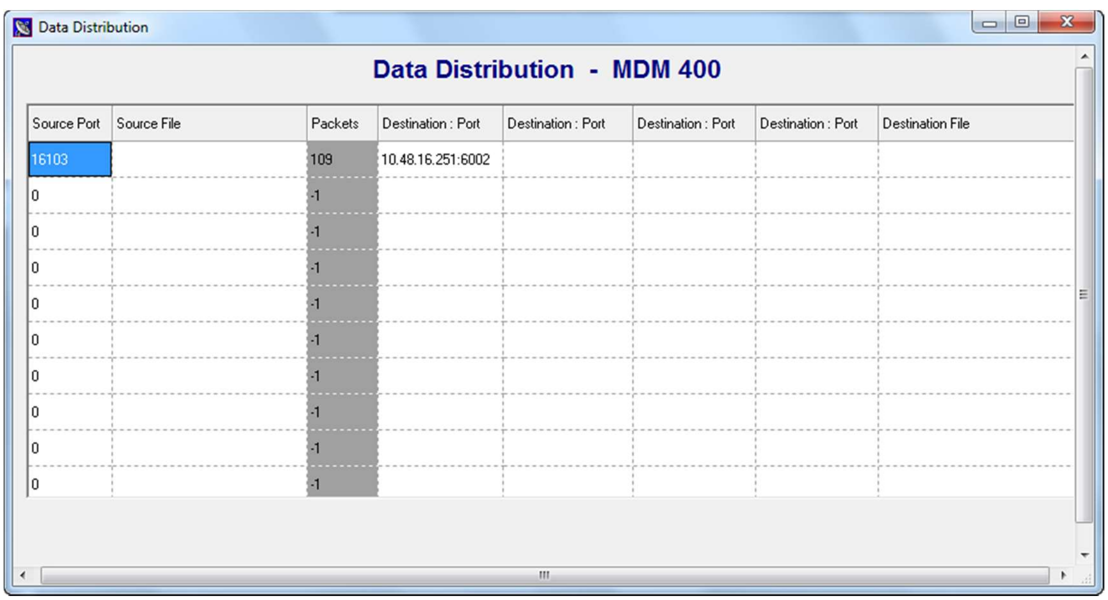

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Settings
Locations
Angular Offsets
ROV. Specific
Depth/Pressure Sensor
Delay (msec.):
0
Disable Heave Sensor

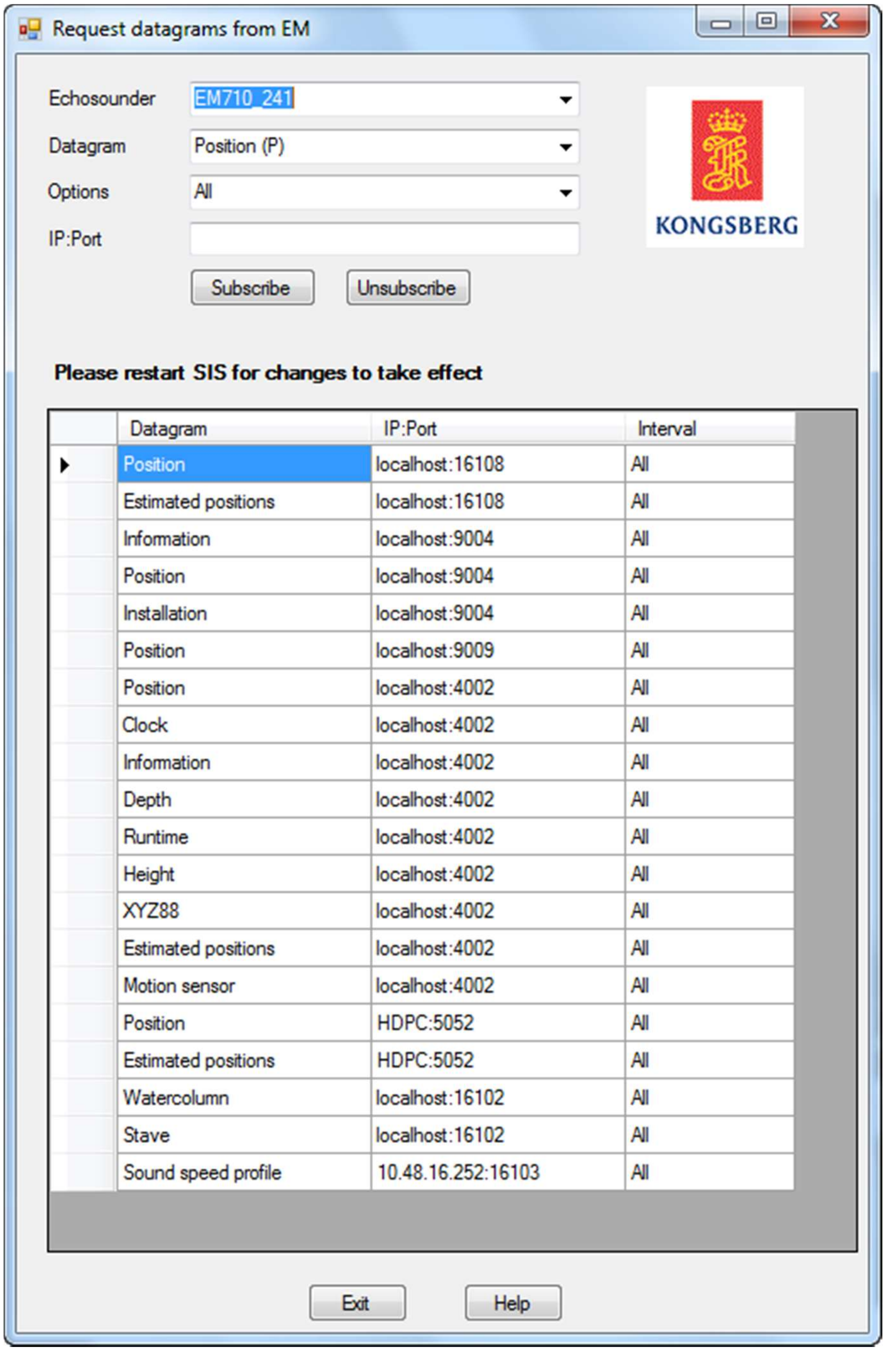

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
System Gain Offset
BS Offset (dB)
0.0
Opening angles
RX Opening angle:
1
TX Opening angle:
0.5


Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Clear all
Run all BISTs
PU BIST Setup
0 = BSP Test
7 = TX Channels
1 = TX36 Test
8 = RX Noise Level
2 = RX32 Test
9 = RX Noise Spectrum
3 = TRU Power Test
10 = CPU Test
5 = RX32-BSP Link
15 = Software Date/Version
6 = RX Channels
PU BIST Result
Save BIST
Date
Time
Ser. No.
BIST
Result
Description

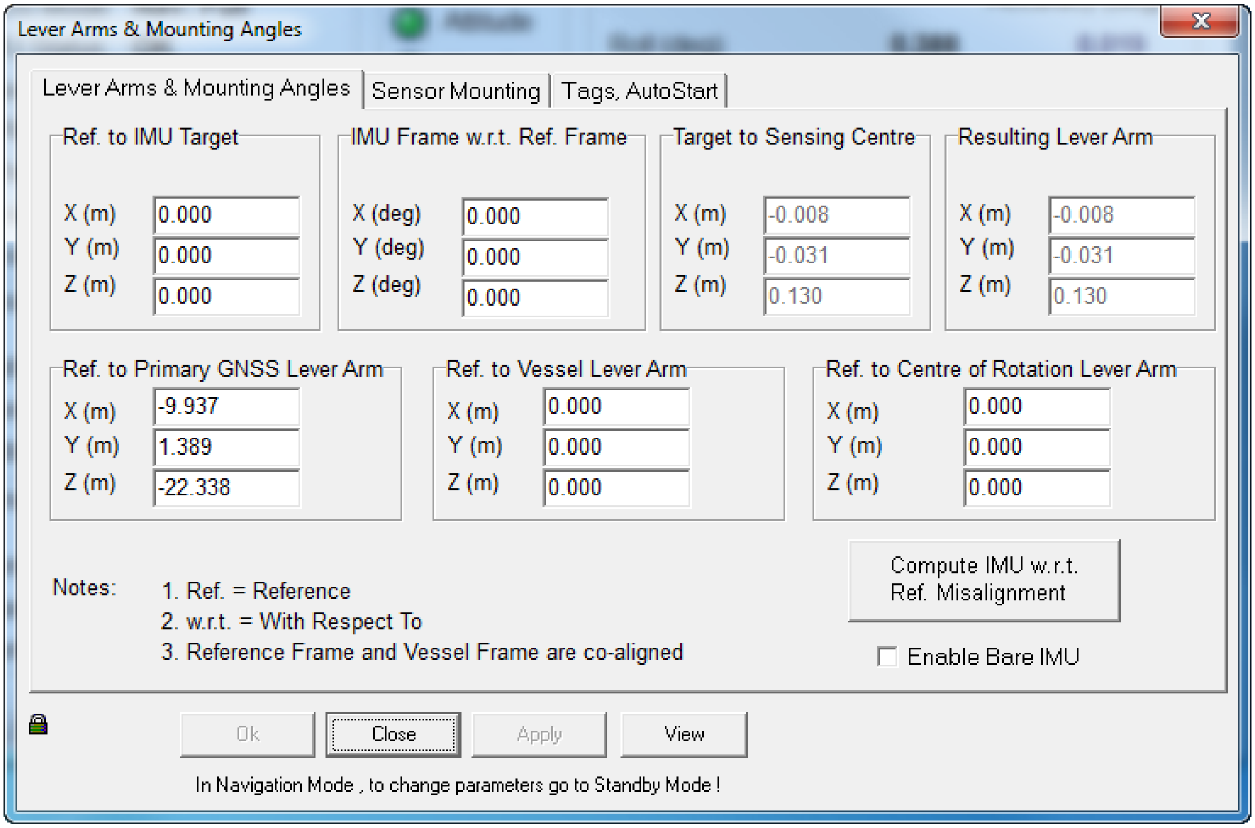

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
PU System Report
System Report.
Path:
D:\sisdata\common\bist
...
Name:

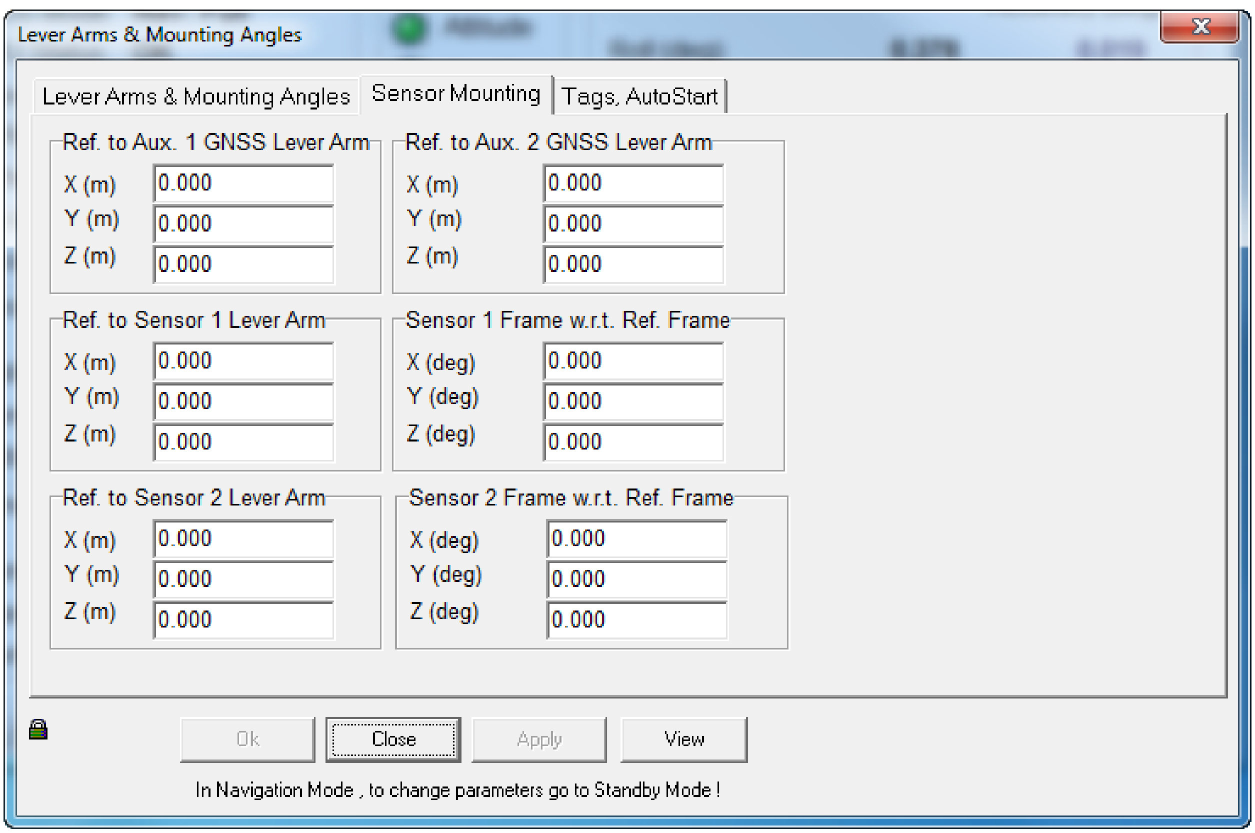

External sensors
Input Setup
Sound Velocity Probe
Port
Probe available
COM1
Probe type
AML SV (C)
SVP Logger
Port
SVP Logger avail
Barometer
Port
Barometer avail
Geodimeter
Port
Geodimeter avail
Echosounder
Real time Tide
Port
Realtime Tide avail
Heading
Sensor name
Serial
Port
Ethernet
IP addr.
Port addr.
Add
Compass deviation file:
...
Position
Sensor name
Serial
Port
Ethernet
IP addr.
Port addr.
Position delay (sec.):
0.00
Forward (X)
Starboard (Y)
Downward (Z)
Add
Location offset (m)
0.00
0.00
0.00
Output Setup
Auto Pilot
Port
Auto Pilot avail
Enable Output
Dyn Pos
Port
Serial
IP addr.
Port addr.
Ethernet
Depth below keel
Port
Depth below keel avail
Port
COM1
Baud rate:
19200
Data bits
8
Stop bits:
1
Parity:
NONE
Waterline for NMEA single beam(m). Downward (Z)
0.00
OK
CANCEL

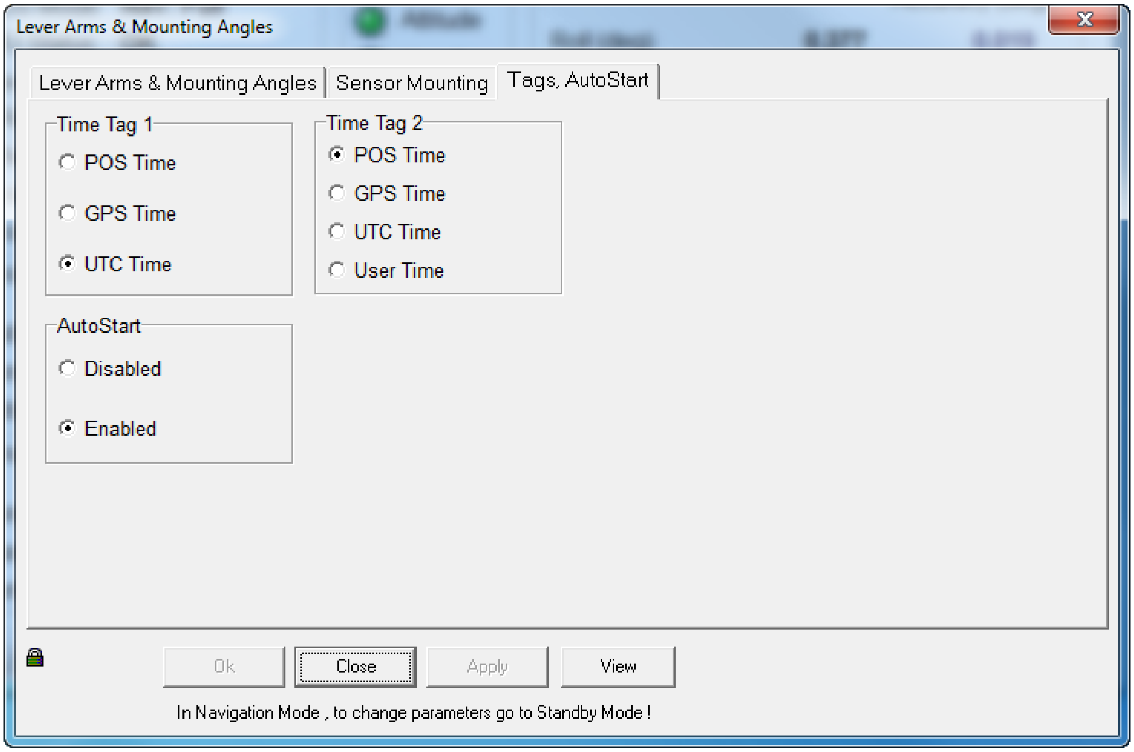

Data Distribution
Data Distribution - MDM 400
Source Port
Source File
Packets
Destination : Port
Destination : Port
Destination : Port
Destination : Port
Destination File
16103
109
10.48.16.251:6002
0
-1
0
-1
0
-1
0
-1
0
-1
0
-1
0
-1
0
-1
0
-1

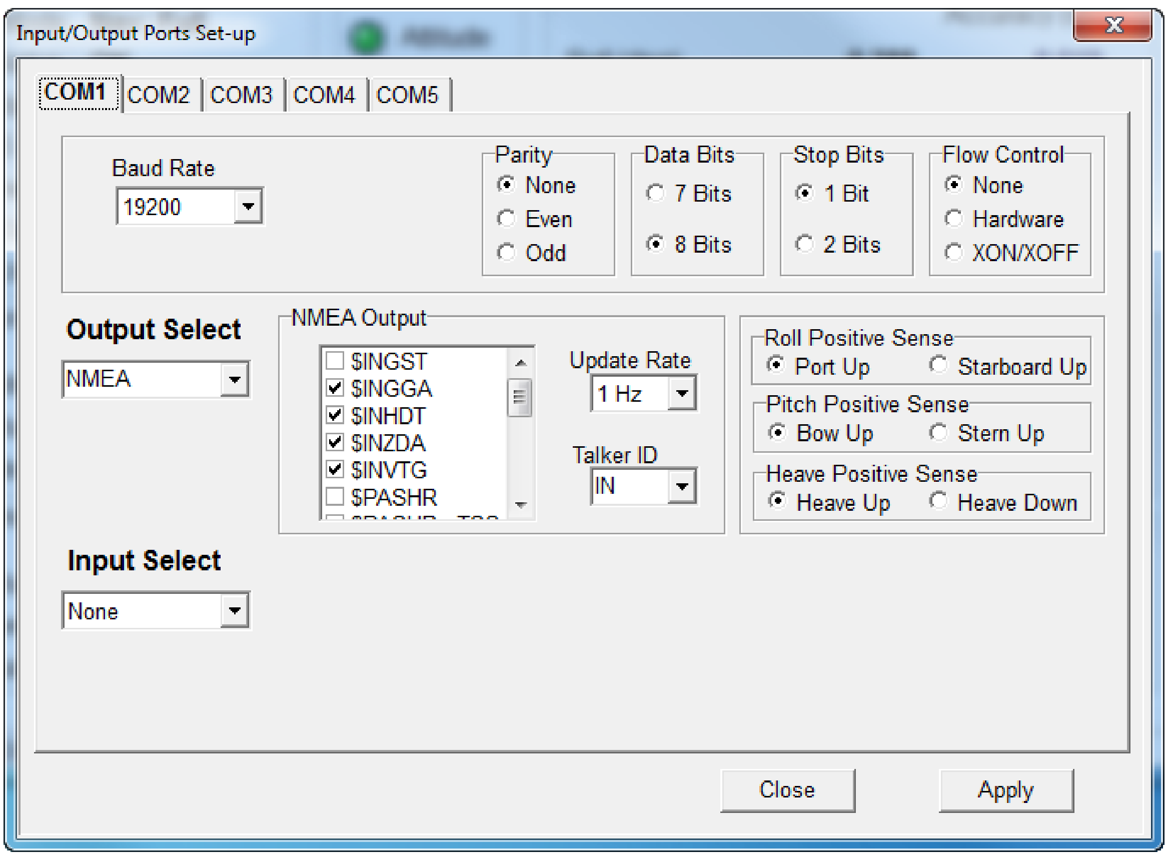

Request datagrams from EM
Echosounder
EM710_241
Datagram
Position (P)
Options
All
IP:Port
Subscribe
Unsubscribe
KONGSBERG
Please restart SIS for changes to take effect
Datagram
IP:Port
Interval
Position
localhost:16108
All
Estimated positions
localhost:16108
All
Information
localhost:9004
All
Position
localhost:9004
All
Installation
localhost:9004
All
Position
localhost:9009
All
Position
localhost:4002
All
Clock
localhost:4002
All
Information
localhost:4002
All
Depth
localhost:4002
All
Runtime
localhost:4002
All
Height
localhost:4002
All
XYZ88
localhost:4002
All
Estimated positions
localhost:4002
All
Motion sensor
localhost:4002
All
Position
HDPC:5052
All
Estimated positions
HDPC:5052
All
Watercolumn
localhost:16102
All
Stave
localhost:16102
All
Sound speed profile
10.48.16.252:16103
All
Exit
Help

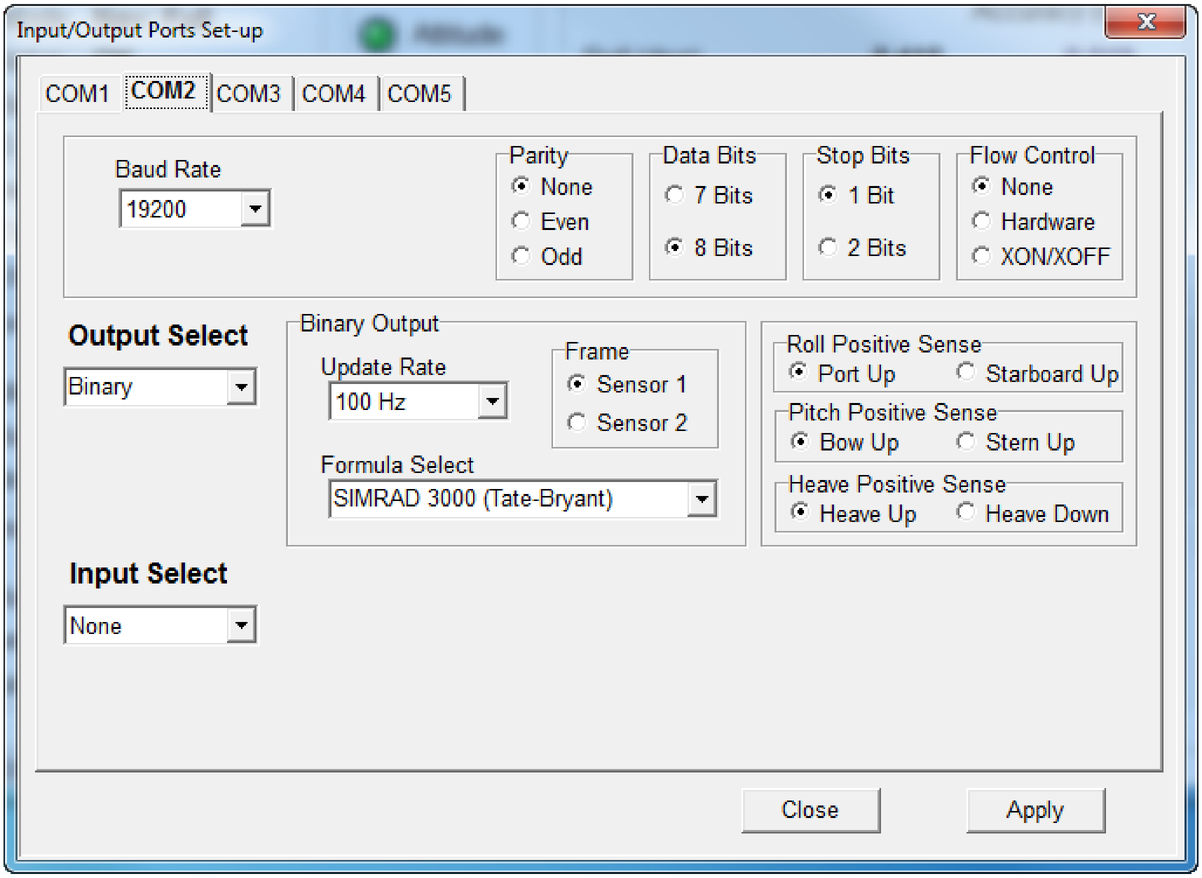
10.1.2 POS M/V

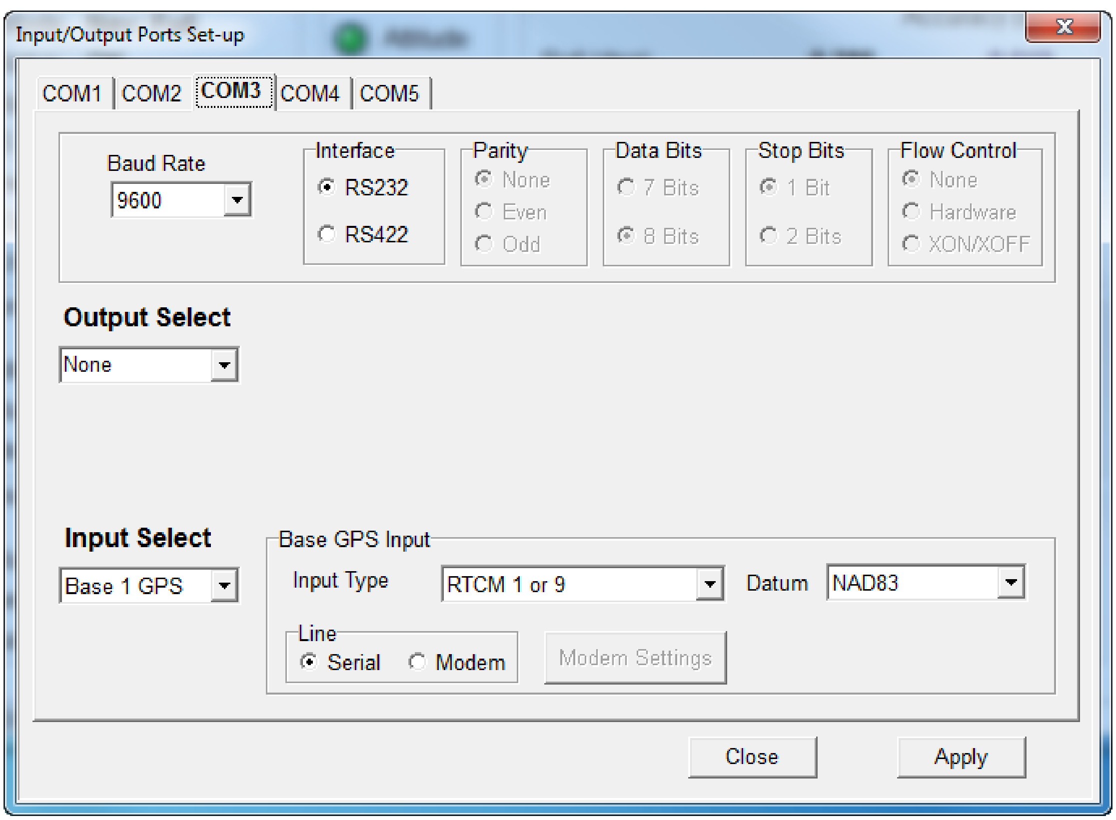

Lever Arms & Mounting Angles
Lever Arms & Mounting Angles
Sensor Mounting
Tags, AutoStart
Ref. to IMU Target
X (m) 0.000
Y (m) 0.000
Z (m) 0.000
IMU Frame w.r.t. Ref. Frame
X (deg) 0.000
Y (deg) 0.000
Z (deg) 0.000
Target to Sensing Centre
X (m) -0.008
Y (m) -0.031
Z (m) 0.130
Resulting Lever Arm
X (m) -0.008
Y (m) -0.031
Z (m) 0.130
Ref. to Primary GNSS Lever Arm
X (m) -9.937
Y (m) 1.389
Z (m) -22.338
Ref. to Vessel Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000
Ref. to Centre of Rotation Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000
Notes:
1. Ref. = Reference
2. w.r.t. = With Respect To
3. Reference Frame and Vessel Frame are co-aligned
Compute IMU w.r.t. Ref. Misalignment
Enable Bare IMU
Ok
Close
Apply
View
In Navigation Mode , to change parameters go to Standby Mode !

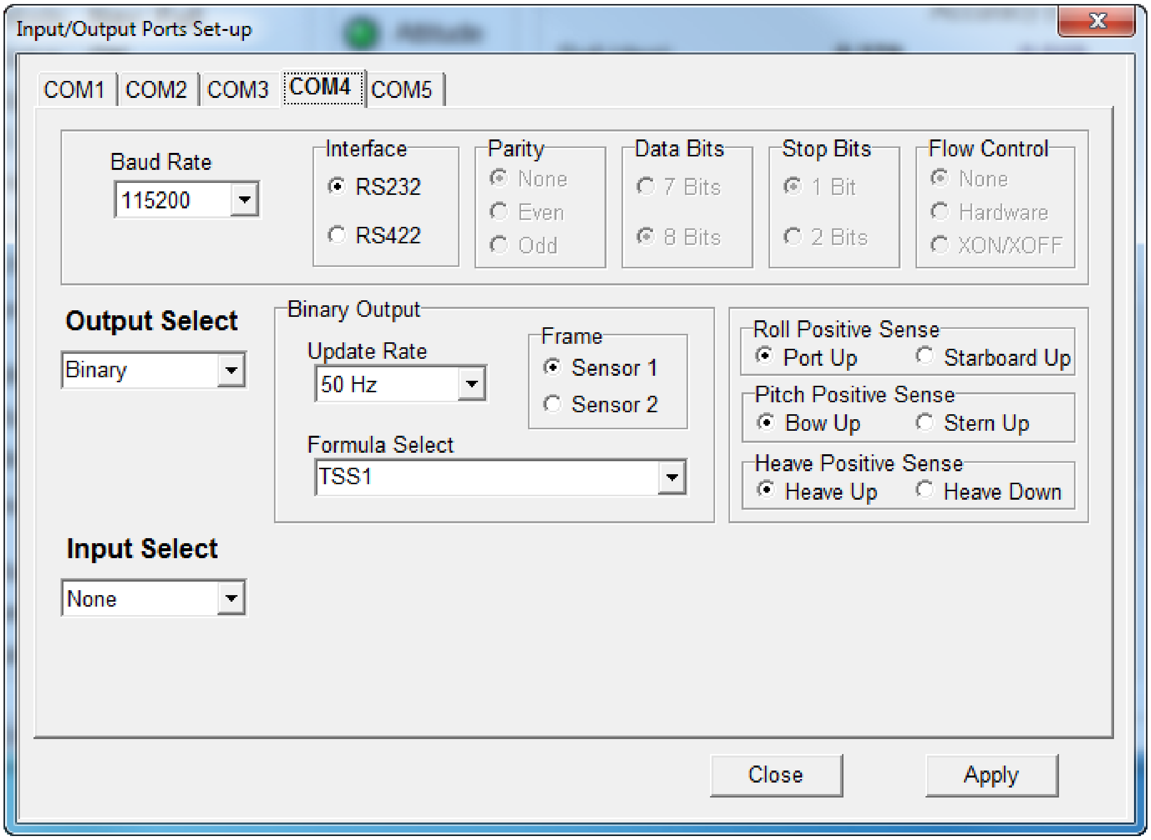

Lever Arms & Mounting Angles
Lever Arms & Mounting Angles
Sensor Mounting
Tags, AutoStart
Ref. to Aux. 1 GNSS Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000
Ref. to Aux. 2 GNSS Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000
Ref. to Sensor 1 Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000
Sensor 1 Frame w.r.t. Ref. Frame
X (deg) 0.000
Y (deg) 0.000
Z (deg) 0.000
Ref. to Sensor 2 Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000
Sensor 2 Frame w.r.t. Ref. Frame
X (deg) 0.000
Y (deg) 0.000
Z (deg) 0.000
Ok
Close
Apply
View
In Navigation Mode , to change parameters go to Standby Mode !

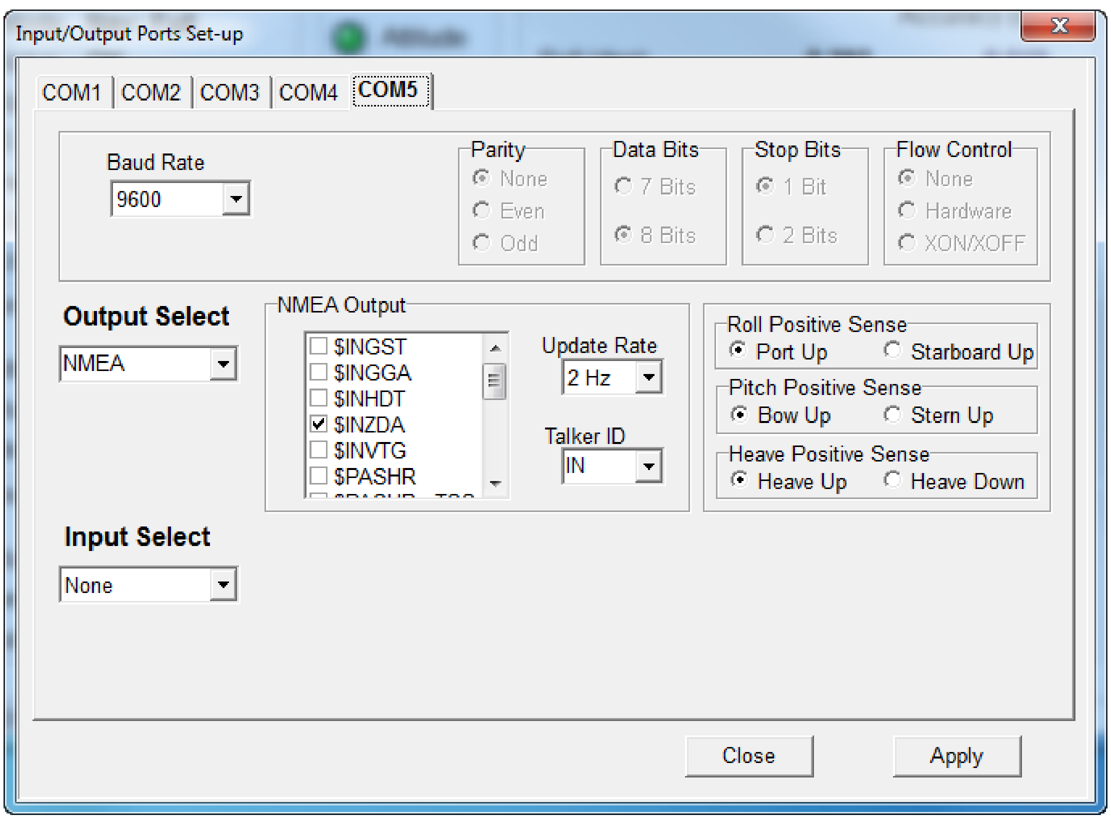

Lever Arms & Mounting Angles
Lever Arms & Mounting Angles
Sensor Mounting
Tags, AutoStart
Time Tag 1
POS Time
GPS Time
UTC Time
Time Tag 2
POS Time
GPS Time
UTC Time
User Time
AutoStart
Disabled
Enabled
Ok
Close
Apply
View
In Navigation Mode , to change parameters go to Standby Mode !

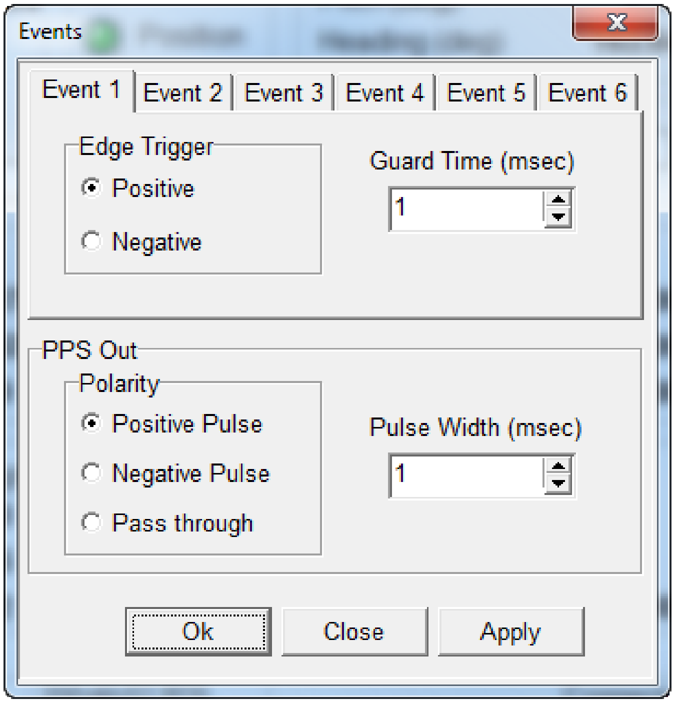

Input/Output Ports Set-up
COM1
COM2
COM3
COM4
COM5
Baud Rate
19200
Parity
None
Even
Odd
Data Bits
7 Bits
8 Bits
Stop Bits
1 Bit
2 Bits
Flow Control
None
Hardware
XON/XOFF
Output Select
NMEA
NMEA Output
$INGST
$INGGA
$INHDT
$INZDA
$INVTG
$PASHR
Update Rate
1 Hz
Talker ID
IN
Roll Positive Sense
Port Up
Starboard Up
Pitch Positive Sense
Bow Up
Stern Up
Heave Positive Sense
Heave Up
Heave Down
Input Select
None
Close
Apply

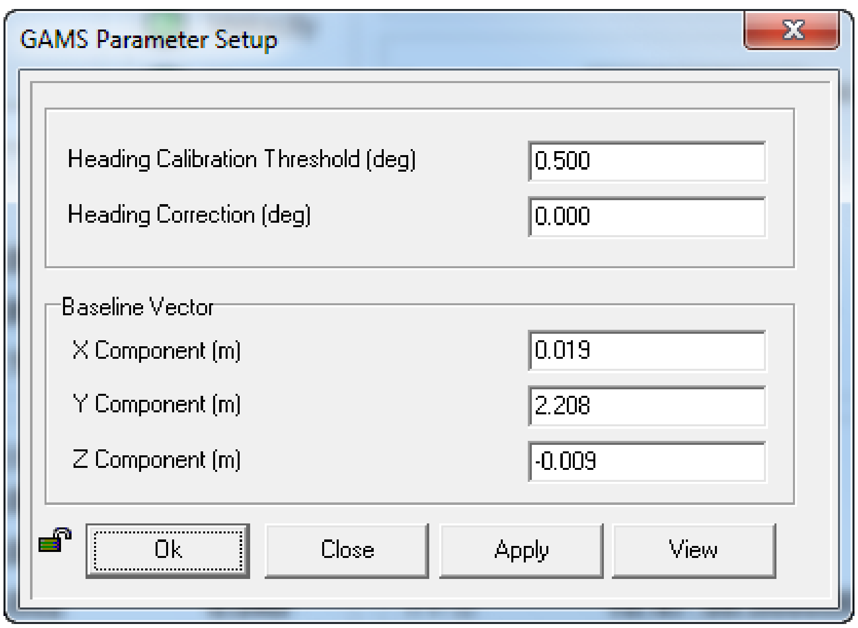

Input/Output Ports Set-up
COM1
COM2
COM3
COM4
COM5
Baud Rate
19200
Parity
None
Even
Odd
Data Bits
7 Bits
8 Bits
Stop Bits
1 Bit
2 Bits
Flow Control
None
Hardware
XON/XOFF
Output Select
Binary
Binary Output
Update Rate
100 Hz
Frame
Sensor 1
Sensor 2
Formula Select
SIMRAD 3000 (Tate-Bryant)
Roll Positive Sense
Port Up
Starboard Up
Pitch Positive Sense
Bow Up
Stern Up
Heave Positive Sense
Heave Up
Heave Down
Input Select
None
Close
Apply

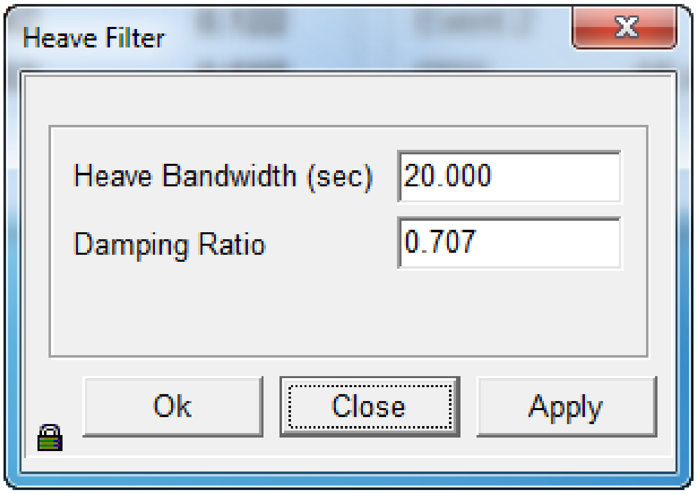

Input/Output Ports Set-up
COM1
COM2
COM3
COM4
COM5
Baud Rate
9600
Interface
RS232
RS422
Parity
None
Even
Odd
Data Bits
7 Bits
8 Bits
Stop Bits
1 Bit
2 Bits
Flow Control
None
Hardware
XON/XOFF
Output Select
None
Input Select
Base 1 GPS
Base GPS Input
Input Type
RTCM 1 or 9
Datum
NAD83
Line
Serial
Modem
Modem Settings
Close
Apply


Input/Output Ports Set-up
COM1
COM2
COM3
COM4
COM5
Baud Rate
115200
Interface
RS232
RS422
Parity
None
Even
Odd
Data Bits
7 Bits
8 Bits
Stop Bits
1 Bit
2 Bits
Flow Control
None
Hardware
XON/XOFF
Output Select
Binary
Binary Output
Update Rate
50 Hz
Frame
Sensor 1
Sensor 2
Formula Select
TSS1
Roll Positive Sense
Port Up
Starboard Up
Pitch Positive Sense
Bow Up
Stern Up
Heave Positive Sense
Heave Up
Heave Down
Input Select
None
Close
Apply


Input/Output Ports Set-up
COM1
COM2
COM3
COM4
COM5
Baud Rate
9600
Parity
None
Even
Odd
Data Bits
7 Bits
8 Bits
Stop Bits
1 Bit
2 Bits
Flow Control
None
Hardware
XON/XOFF
Output Select
NMEA
NMEA Output
$INGST
$INGGA
$INHDT
$INZDA
$INVTG
$PASHR
Update Rate
2 Hz
Talker ID
IN
Roll Positive Sense
Port Up
Starboard Up
Pitch Positive Sense
Bow Up
Stern Up
Heave Positive Sense
Heave Up
Heave Down
Input Select
None
Close
Apply


Events
Event 1
Event 2
Event 3
Event 4
Event 5
Event 6
Edge Trigger
Positive
Negative
Guard Time (msec)
1
PPS Out
Polarity
Positive Pulse
Negative Pulse
Pass through
Pulse Width (msec)
1
Ok
Close
Apply


GAMS Parameter Setup
Heading Calibration Threshold (deg)
0.500
Heading Correction (deg)
0.000
Baseline Vector
X Component (m)
0.019
Y Component (m)
2.208
Z Component (m)
-0.009
Ok
Close
Apply
View


Heave Filter
Heave Bandwidth (sec)
20.000
Damping Ratio
0.707
Ok
Close
Apply

NOAA Form 57-11-13D
(10-12)

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

DECK LOG – WEATHER OBSERVATION SHEET

NOAA Ship	TIME ZONE	DAY OF WEEK	DATE (dd mmm yyyy)
THOMAS JEFFERSON S-222	+4	~~TUESDAY~~ WED	12 OCT 2016

KS

TIME	POSITION		SKY CONDITION	PRESENT WEATHER	VISIBILITY (nm)	WIND		SEA LEVEL Press. (mb)	SEA WAVE Height (ft)	SWELL WAVES		TEMPERATURE (°C)		
	LATITUDE	LONGITUDE				Dir. (true)	Speed (kts)			Dir. (true)	Height (ft)	SEA WATER	DRY BULB	WET BULB
00														
01														
02														
03														
04														
05														
06														
07														
08	36°57.2'N	076°17.9'W	CLR	NSW	10T	010	5	1028	–	–	–	–	13.8	13
09														
10														
11														
12														
13														
14														
15														
16	36°58.8'N	076°20.7'W	FEW	~~CA~~ -BR	10	066	9	1021.6	–	–	–	20.3	19.8	16.7
17	36°58.9'N	76°20.7'W	FEW	-BR	10T	060	11	1020.1	–	–	–	20.2	21.2	19.6
18	36°58.2'N	076°21.2'W	FEW	-BR	10T	072	11	1020.4	–	–	–	19.1	19.2	16.9
19	37°00.2'N	076°16.5'W	FEW	BR	10	087	12	1020.9	–	–	–	20.5	19.1	16.3
20														
21														
22														
23														

SUPERSEDES NOAA Form 77-13D (3-76)

NOAA Form 57-11-13D
(10-12)

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

DECK LOG – WEATHER OBSERVATION SHEET

NOAA Ship THOMAS JEFFERSON S-222	TIME ZONE	DAY OF WEEK	DATE (dd mmm yyyy)
	+4	~~8~~ THURS	13 OCT 2016

TIME	POSITION		SKY CON-DITION	PRESENT WEATHER	VISI-BILITY (nm)	WIND		SEA LEVEL Press. (mb)	SEA WAVE Height (ft)	SWELL WAVES		TEMPERATURE (°C)		
	LATITUDE	LONGITUDE				Dir. (true)	Speed (kts)			Dir. (true)	Height (ft)	SEA WATER	DRY BULB	WET BULB
00	37° 27.86' N	076° 42.6' W	FAIR	NSW	10	108	8	1019.0	NA	NA	NA	20.3	18	17
01	37° 32.5' N	076° 06.1' W	FAIR	NSW	10+	090	2	1019.9	N/A	N/A	N/A	19.9	17.9	17.5
02	37° 34.3' N	076° 08.0' W	FAIR	NSW	10+	093	4	1019.2	N/A	N/A	NA	19.8	18.2	17.0
03	37° 35.16' N	076° 08.6' W	FAIR	NSW	20+	115	3	1018.7	N/A	N/A	N/A	19.2	18.1	17
04	37° 34.2' N	076° 07.1' W	FAIR	NSW	10+	012	4	1018.6	—	—	—	19.2	18.0	17.1
05	37° 32.2' N	076° 03.8' W	CLR	AR	10	015	2	1018.5	—	—	—	19.5	17.8	17.1
06	37° 33.0' N	076° 13.6' N	CLR	AR	10	345	2	1018.6	—	—	—	19.4	17.8	17.2
07	37° 34.3' N	076° 05.2' W	FEW	AR	10	115	2	1018.3	—	—	—	19.1	17.4	17.1
08	37° 34.1 N	076° 07.7' W	CLR	NSW	10	250	4	1018.7	—	—	—	19.6	18.5	17.5
09	—	—	—	NOT	OBSERVED				—	—	—	—	—	—
10	37° 35.7 N	076° 05.8' W	CLR	Patchy Fog	10	224	5	1019.1	—	—	—	19.8	17.1	17.1
11	37° 37.6 N	076° 10.5' N	PC	NSW	10	233	9	1018.5	—	—	—	19.8	17.9	16.9
12	37° 35.7' N	076° 08.7' W	FEW	NSW	10+	268	6	1018.3	—	—	—	20.2	20.5	19.5
13	37° 35.3' N	076° 07.6' W		NOT	OBSERVED				—	—	—	—	—	—
14	37° 32.4' N	076° 05.9' W	PC	NSW	10+	163	3	1017.1	—	—	—	20.6	22.0	20.5
15	—	—	—	NOT	OBSERVED				—	—	—	—	—	—
16	37° 37.0' N	076° 04.5' W	PC	-BR	10	330	5	1016.6	—	—	—	21.1	17.3	15.6
17	37° 33.7' N	076° 06.1' W	PC	NSW	10	176	2.0	1016.5	—	—	—	20.7	20.5	17.5
18	37° 38.5' N	076° 09.9' W	PC	NSW	10	045	6.0	1017.1	<1	—	—	21.1	20.3	17.9
19	37° 37' N	076° 08' W	PC	NSW	10	011	7.5	1018.0	<1	—	—	20.9	19.8	18.0
20	37° 34 N	076° 06.3' W	CLR	NSW	10	016	18	1018.1	<1	—	—	20.2	20.4	17.3
21	37° 37.4	076° 09' W	CLR	NSW	10	017	15	1019.1	<1	—	—	20.3	20.3	16.4
22	37° 35.5' N	076° 06.5' W	CLR	NSW	10	017	17	1019.7	<1	—	—	19.8	19.8	16.7
23	37° 34.9' N	076° 06.6' W	CLR	NSW	10	015	15	1020.4	1-2	—	—	19.8	19.5	16.8

SUPERSEDES NOAA Form 77-13D (3-76)

NOAA Form 57-11-13D
(10-12)

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

DECK LOG – WEATHER OBSERVATION SHEET

NOAA Ship THOMAS JEFFERSON S-222	TIME ZONE +4	DAY OF WEEK FRIDAY	DATE (dd mmm yyyy) 14 OCT 2016

TIME	POSITION		SKY CON-DITION	PRESENT WEATHER	VISI-BILITY	WIND		SEA LEVEL Press.	SEA WAVE Height	SWELL WAVES		TEMPERATURE (°C)			
	LATITUDE	LONGITUDE			(nm)	Dir. (true)	Speed (kts)	(mb)	(ft)	Dir. (true)	Height (ft)	SEA WATER	DRY BULB	WET BULB	
00	37°35.0'N	076°06.0'W	OVC	+BR	10	355	23.3	1020	2-3	340	2-3	19.8	19.1	15.6	
01	37°35.7'N	076°07.3'W	OVC	+BR	10+	[illegible]	23	1021	2-3	340	1-2	19.9	19.0	16.5	
02	37°28.8'N	076°06.2'W	OVC	+BR	10+	354	27	1022	0-1	340	0-1	19.8	17.0	16.0	
03	37°23.7'N	076°06.0'W	OVC	+BR	10+	352	22	1022	0-1	340	0-1	20.2	17.0	16.0	
04	37°13.6'N	076°07.4'W	MC	+BR	10	359	22	1022	1	330	1	20.2	17.1	14.3	
05	37°06.4'N	076°01.3'W	MC	BR	10	012	20	1022.6	1	320	2	19.6	17	13.3	
06	37°00.0'N	076°02.1'W	MC	BR	10	013	18	1023.1	1-2	[illegible]	2	19.3	15.9	12.4	
07	36°57.9'N	076°04.0'W	PC	BR	10	070	18	1024.8	2-3	330	2-3	19.7	15.5	13.7	
08	37°00.3'N	076°13.7'W	PC	BR	10	038°	19	1023.9	2	335	2	20.2	13.7	12.7	
09				NOT	OBSERVED										
10				NOT	OBSERVED										
11				NOT	OBSERVED										
12				NOT	OBSERVED										
13				NOT	OBSERVED										
14	36°59.0'N	076 19.9'W	SCT	~~BCF~~ NSW	10	022	12	1025.7	1	191	1	20.0	17.0	12.5	[illegible]
15	3°05.0'N	076 20.1'W	SCT	NSW	10	039	38	1025.7	1	055	1	20.0	17.0	12.1	
16	36°58.9'N	076°20.1'W	MC	BR	10	040	13	1025.7	1	—	—	20.0	16.0	11.6	
17															
18	36°57.6'N	076°07.9'W	MC	-BR	10	025	8	1025.3	1	045	1	19.8	16.0	11.3	
19	36°56.1'N	075°53.0'W	MC	-BR	10	053	7	1025.3	1-2	045	2	20.0	15.7	11.6	
20	36°38.3'N	075°17.1	MC	-BR	10	030	9	1025.3	1-2	045	2	19.9	15.6	12	
21	37°00.9'N	075°27.2'W	~~CLR~~ MC	BR	10	046	11	1025.9	1-2	045	2	19.4	15.5	11.6	KS
22	37°03.3N	075°15.3'W	~~CLR~~ MC	-BR	10	054	7	1026.4	~~1-2~~ 2-3	040	3	19.3	15.3	11.9	KS
23	37°08.7	075°09.7	MC	BR	10	050	11	1026.4	~~4-5~~ 2-3	040	4-5	19.1	15.2	12.3	KS

SUPERSEDES NOAA Form 77-13D (3-76)

NOAA Form 57-11-13D
(10-12)

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

DECK LOG – WEATHER OBSERVATION SHEET

NOAA Ship	TIME ZONE	DAY OF WEEK	DATE (dd mmm yyyy)
THOMAS JEFFERSON S-222	+4	SATURDAY	15 OCT 2016

TIME	POSITION		SKY CONDITION	PRESENT WEATHER	VISIBILITY (nm)	WIND		SEA LEVEL Press. (mb)	SEA WAVE Height (ft)	SWELL WAVES		TEMPERATURE (°C)		
	LATITUDE	LONGITUDE				Dir. (true)	Speed (kts)			Dir. (true)	Height (ft)	SEA WATER	DRY BULB	WET BULB
00	37° 14.6'N	075° 02.0'W	FAIR	NSW	10	074	12.7	1026.5	2-3	040	3-4	19	15.2	11.8
01	37° 22'N	074° 53.8'W	FAIR	NSW	10	050	10	1026.7	2-3	045	3-4	18.4	15.2	11.8
02	37° 25'N	074° 49'W	FAIR	BR	10	060	13	1026.7	2-3	050	3-4	18.5	15.3	11.7
03	37° 31'N	074° 41.0'W	FAIR	BR	10	076	11	1026	1-2	010	3-4	17.8	15.6	11.7
04	37° 26.8'N	074° 35.2'W	FAIR	BR	10	080	11	1025.8	1-2	020	3-4	18.2	15.8	11.6
05	37° 42.1'N	074° 28.5'W	FAIR	BR	10	015	8	1025.8	1-2	030	1-2	18.3	15.9	11.8
06	37° 48.3'N	074° 21.3'W	FAIR	BR	10	015	3	1025.9	1-2	030	1-2	17.8	16.0	12.0
07	37° 53.6'N	074° 15.6'W	FAIR	BR	10	350	7	1026.7	1-2	060	1-2	18.9	16.3	12.7
08														
09	37° 53.1'N	074° 15.5'W	FAIR	-BR	10	020	8	1027.9	1-2	070	1-2	18.7	16.5	13.2
10	37° 52.9'N	074° 15.6'W	FAIR	BR	10	033	13	1028.5	1-2	070	1-2	18.6	16.4	13.2
11	37° 52.9'N	074° 14.18'W	FAIR	BR	10	030	13	1028.1	1-2	075	1-2	18.6	16.4	13.4
12	37° 53.7'N	074° 15.0'W	CLR	BR	10	033	13	1028	1-2	080	1-2	18.8	18.0	13.8
13	37° 52.4'N	074° 14.3'W	HZ	BR	10	038	15	1027.1	1-2	070	2-3	18.9	17.1	14.3
14	37° 51.7'N	074° 09.0'W	FEW	-BR	10+	037	13	1026.6	1-2	070	1-2	20.3	17.8	14.4
15	37° 48.7'N	074° 06.1'W	FEW	-BR	10+	065	10	1026.4	1-2	060	1-2	20.4	19.8	14.9
16	37° 52.3'N	074° 03.1'W	FEW	NSW	10+	105	13	1025.8	1-2	050	1-2	20.2	18.6	14.0
17														
18	38° 11.0'N	073° 51.5'W	FEW	NSW	10+	115	12	1025.5	<1	040	1-2	20.6	18.0	12.9
19	38° 19.9'N	073° 43.1'W	FEW	-BR	10+	095	12	1025.8	1-2	045	2-3	20.4	17.9	13.6
20	38° 27.1'N	073° 34.6'W	FEW	-BR	10+	103	11	1025.8	1-2	045	2-3	20.5	17.5	13.0
21	38° ~~31.29'~~ 35.2'N	073° 24.8'W	FEW	-BR	10+	122	9	1025.8	1-2	045	2-3	20.0	17.0	12.5
22	38° 43.0'N	073° 15.3'W	FEW	-BR	10+	135	8	1025.8	1-2	045	2-3	20.4	16.8	12.4
23	38° 51.7'N	073° 04.4'W	FEW	-BR	10+	136	9	1025.6	1-2	045	2-3	20.6	16.8	12.1

KS

SUPERSEDES NOAA Form 77-13D (3-76)

NOAA Form 57-11-13D
(10-12)

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

DECK LOG – WEATHER OBSERVATION SHEET

NOAA Ship	TIME ZONE	DAY OF WEEK	DATE (dd mmm yyyy)
THOMAS JEFFERSON S-222	+4	~~SATURDAY~~ SUNDAY	16 OCT 2016

TIME	POSITION		SKY CONDITION	PRESENT WEATHER	VISIBILITY (nm)	WIND		SEA LEVEL Press. (mb)	SEA WAVE Height (ft)	SWELL WAVES		TEMPERATURE (°C)		
	LATITUDE	LONGITUDE				Dir. (true)	Speed (kts)			Dir. (true)	Height (ft)	SEA WATER	DRY BULB	WET BULB
00	38°58'N	072°56'W	FAIR	NSW	10+	188	8.4	1025.5	1-2	075	2-3	20.3	16.7	12.5
01					NOT	OBSERVED								
02					NOT	OBSERVED								
03	39°09.0'N	072°43'W	FAIR	NSW	10	190	2	1024	—	065	1-2	20.9	16.4	12.3
04	39°10.4'N	072°44.4'W	MC/BKN	NSW	10	235	3	1024.4	<1	075	1-2	20.7	16.5	12.7
05	39°09.2'N	072°41.9'W	ML	-BR	10	251	9	1024.1	—	090	2	20.7	16.5	12.1
06	39°09.3'N	072°40.0'W	PC/SCT	NSW	10+	205	4	1023.8	<1	080	2-3	20.7	16.5	12.2
07	39°07.9'N	072°41.2'W	PC/SCT	NSW	10+	205	6	1023.5	<1	080	2-3	21.2	16.8	12.7
08	39°15.7'N	072°26.2'W	PC/SCT	NSW	10+	225	4	1023.2	<1	080	2-3	21.1	17.2	12.8
09	39°27.0'N	072°31.5'W	PC	NSW	10+	205	8	1023.0	<1	085	2-3	21.1	17.2	~~4.~~ 12.7 KS
10	39°36.9'N	072°27.5'W	PC	NSW	10+	217	8	1022.5	<1	085	1-2	21.0	17.3	13.5
11	39°37.9'N	072°28.5'W	SCT	-BR	10+	239	11	1021.3	1	110	1-2	20.5	17.8	13.8
12	39°37.3'N	072°29.0'W	SCT	-BR	10+	231	11.8	1021.0	1	110	1-2	20.5	18.5	14.3
13	39°37.2'N	072°28.2'W	-SCT	BR	10+	241	11.9	1020.8	1-2	120	2-3	20.5	17.9	13.8
14	39°37.3'N	072°28.9'W	SCT	BR	10+	250	12.9	1020.0	1-2	100	2-3	20.5	17.8	14.3
15	39°33.3'N	072°32.9'W	SCT	BR	10+	225	17	1017.8	1-2	120	2-3	20.4	18.0	14.4
16	39°20.7'N	072°22.9'W	SCT	BR	10+	245	14	1017.2	1-2	110	2-3	21.0	18.1	14.5
17	39°18.7'N	072°20.8'W	FEW	BR	10+	~~235~~ 225	15	1016.6	1-2	100	2-3	21.6	18.4	15.4
18	~~39°17.2'N~~	~~072°22.8'W~~	~~FEW~~	~~BR~~	~~10+~~	~~250~~	~~17~~	~~1017.1~~	~~1-2~~	~~100~~	~~2-3~~	~~21.0~~	~~18.6~~	~~15.8~~
19														
20	39°17.2'N	072°22.8'W	FEW	BR	10+	250	17	1017.1	1-2	100	2-3	21.6	18.6	15.8
21	39°19.5'N	072°19.9'W	FEW	BR	10+	249	19	1016.7	1-2	100	2-3	21.6	19.2	16.2
22	39°18.6'N	072°21.4'W	FEW	BR	10+	240	17	1016.6	1-2	110	2-3	21.6	19.3	16.4
23	39°17.8'N	072°20.07'W	FEW	BR	10+	246	20	1016.7	2	110	3	21.7	19.8	16.5

SUPERSEDES NOAA Form 77-13D (3-76)

NOAA Form 57-11-13D
(10-12)

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

DECK LOG – WEATHER OBSERVATION SHEET

NOAA Ship	TIME ZONE	DAY OF WEEK	DATE (dd mmm yyyy)
THOMAS JEFFERSON S-222	+4	MONDAY	17 OCT 2016

TIME	POSITION		SKY CONDITION	PRESENT WEATHER	VISIBILITY (nm)	WIND		SEA LEVEL Press. (mb)	SEA WAVE Height (ft)	SWELL WAVES		TEMPERATURE (°C)		
	LATITUDE	LONGITUDE				Dir. (true)	Speed (kts)			Dir. (true)	Height (ft)	SEA WATER	DRY BULB	WET BULB
00	39° 18.3'N	072° 21.1'W	CLR	FAIR	10	245	20.5	1015.6	1-2	240	2-3	21.5	19.8	16.8
01	039° 18.6'N	072 21.5'W	CLR	BR	10	~~31~~ 253	~~253~~ 21	1015.9	1-2	240	2-3	21.6	20.0	17.0
02	39° 19 'N	072° 19.9'W	CLR	BR	10	265	20	1015.5	1-2	250	2-3	21.5	19.8	17.2
03														
04														
05	39° 15.9'N	072° 19.7'W	OVC	BR	10	265	15	1014.4	1-2	240	2-3	20.1	20.2	17.7
06	39° 17.1'N	072° 11.7'W	[illegible]	BR	10+	260	15	1014.7	1-2	240	2-3	22.0	20.1	18.1
07	39° 17.6'N	072° 09.3'W	SCT	BR	10				1-2	260	3	21.8	20.5	18.1
08	39° 16.6'N	072° 12.2'W	PC	BR	10+	248	15	1014.7	1-2	260	3	22.1	20.3	18.2
09	39° 17.7'N	072° 12.8'W	PC	BR	10+	244	17	1014.9	1-2	260	3	21.8	20.5	18.4
10	39° 17.7'N	072° 11.3'W	PC	BR	10+	243	20	1013.7	1-2	250	3	21.9	21.1	18.9
11	39° 18.0'N	072° 11.57'W	PC	BR	10+	243	19	1013.4	~~3~~	255	3	21.9	21.5	19.1
12	39° 18.7'N	072° 12.2'W	CLR	BR	10+	247	19	1013.8	2-3	275	2-3	21.7	20.8	18.9
13	← NOT OBS; DRILLS →													
14	39° 17.4'N	072° 12.4'W	CLR	BR	10+	259	18	1012.8	2-3	275	2-3	21.8	21.2	18.6
15														
16	39° 18.1'N	072° 11.7'W	CLR	BR	10	250	17	1012.0	2-3	210	2-3	22.0	21.2	18.6
17	39° 18.5'N	072° 10.9'W	CLR	BR	10+	242	14	1012.2	2-3	210	2-3	21.6	21.5	18.9
18	39° 16.9'N	072° 13.7'W	CLR	BR	10	226	14	1012.0	2	210	2-3	21.9	21.0	18.9
19	39° 17.1'N	072° 13.4'W	CLR	BR	10	240	17	1012.1	1-2	210	2-3	22	21.3	19.2
20														
21	39° 09.0'N	072° 14.6'W	CLR	BR	10	226	18	1012.6	1-2	200	2-3	22	21.3	19.7
22	39° 03.4'N	072° 09.9'W	CLR	BR	10	224	19	1012.8	1-2	200	2-3	21.2	21.4	19.6
23	38° 56.6'N	072° 04.0'W	CLR	BR	10	233	19	1012.7	1-2	200	2-3	22.9	22.5	20.0

SUPERSEDES NOAA Form 77-13D (3-76)

NOAA Form 57-11-13D
(10-12)

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

DECK LOG – WEATHER OBSERVATION SHEET

NOAA Ship	TIME ZONE	DAY OF WEEK	DATE (dd mmm yyyy)
THOMAS JEFFERSON S-222	+4	TUESDAY	18 OCT 2016

TIME	POSITION		SKY CONDITION	PRESENT WEATHER	VISIBILITY (nm)	WIND		SEA LEVEL Press. (mb)	SEA WAVE Height (ft)	SWELL WAVES		TEMPERATURE (°C)		
	LATITUDE	LONGITUDE				Dir. (true)	Speed (kts)			Dir. (true)	Height (ft)	SEA WATER	DRY BULB	WET BULB
00	38°55.15'N	072°03.95'W	CLR	BR	10+	237	15	1013.5	1-2	—	2-3	22.1	22.3	19.1
01	39°01.1'N	071°58.0'W	CLR	BR	10+	242	17	1013.6	1-2	—	2-3	22.1	22.2	18.8
02	38°57.35'N	072°03.8'W	CLR	BR	10+	243	19	1013.6	1-2	—	2-3	23.0	22.1	19.6
03	38°59.4'N	072°08.1'W	CLR	BR	10+	235	17	1013.4	1-2	—	2-3	23.1	21.9	19.8
04	39°10.5'N	072°14.5'W	CLR	+BR	10	235	18	1013.3	1-2	210	2-3	22.0	21.5	19.8
05	39°14.7'N	072°20.4'W	CLR	+BR	10	235	17	1013.4	1-2	210	2	21.2	21.1	19.6
06	39°18.5'N	072°21.7'W	CLR	BR	10	235	16	1013.4	1-2	220	2	21.0	21.1	19.2
07	39°18.4'N	072°21.8'W	~~CLR~~ FEW	-BR	10+	225	12	1013.8	1-2	190	2-3	21.0	21.0	19.8
08	39°19.3'N	072°22.0'W	FEW	-BR	10+	220	12	1014.1	1-2	190	2-3	21.4	21.5	20.0
09	39°18.5'N	072°21.1'W	FEW	-BR	10+	213	11	1014.6	1-2	210	2-3	21.5	21.5	20.1
10	39°24.1'N	072°25.4'W	FEW	-BR	10+	209	12	1014.4	1-2	210	2	21.1	21.2	20.1
11	39°33.85'N	072°32.76'W	FEW	-BR	10+	211	12	1013.9	1-2	210	2	20.49	20.9	19.7
12	39°37.5'N	072°37.3'W	CLR	BR	10+	228	18	1013.5	0-1	200	1-2	20.6	18.6	19.3
13	39°29.4'N	072°44.7'W	CLR	BR	10+	215	19	1012.9	0-1	260	1-2	20.0	20.6	19.2
14	39°22.4'N	072°50.7'W	CLR	BR	10+	215	19	1012.6	0-1	190	0-1	21.0	20.8	19.2
15	39°17.5'N	072°56.'W	CLR	BR	10+	200	18	1012.3	1	190	1-2	19.5	20.8	19.1
16	39°09.3'N	073°03.8'W	CLR	BR	10	210	19	1012.4	1	190	1-2	18.7	20.5	19.2
17	39°00.1'N	073°12.3'W	CLR	BR	10+	203	19	1012.2	1	190	1-2	18.6	20.4	19.4
18	38°52.9'N	073°19.9'W	CLR	BR	10	200	18	1012.7	1	190	1-2	19.7	20.3	19.4
19	36°45.4'N	073°27.0'W	CLR	BR	10	200	20	1012.7	1-2	180	2	18.9	20.4	19.3
20	38°37.7'N	073°33.9'W	CLR	BR	10	200	20	1012.7	1-2	190	1-2	18.9	20.8	19.4
21	38°26.2'N	073°44.7'W	CLR	BR	10+	205	23	1013.0	1-2	190	2	19.2	21.1	19.6
22	38°18.6'N	073°51.7'W	CLR	BR	10	212	24	1013.3	~~1-2~~ 2-3	190	~~2-3~~ 3	19.3	20.8	19.4
23	38°10.6'N	073°59.0	CLR	BR	10	215	25	1013.7	3-4	200	4-5	18.4	20.4	18.8

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SUPERSEDES NOAA Form 77-13D (3-76)

NOAA Form 57-11-13D
(10-12)

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

DECK LOG – WEATHER OBSERVATION SHEET

NOAA Ship	TIME ZONE	DAY OF WEEK	DATE (dd mmm yyyy)
THOMAS JEFFERSON S-222	+4	WEDNESDAY	19 OCT 2016

TIME	POSITION		SKY CONDITION	PRESENT WEATHER	VISIBILITY (nm)	WIND		SEA LEVEL Press. (mb)	SEA WAVE Height (ft)	SWELL WAVES		TEMPERATURE (°C)		
	LATITUDE	LONGITUDE				Dir. (true)	Speed (kts)			Dir. (true)	Height (ft)	SEA WATER	DRY BULB	WET BULB
00	38° 04'N	074° 04'W	FAIR	BR	10	222	23	1014	2-3	220	2-3	18.2	20.2	18.8
01	37°55.1'N	074° 14.2'W	FAIR	+BR	10+	210	25	1014.4	2-3	220	2-3	18.9	20.2	19.2
02	37°52.5'N	074°16.7'W	FAIR	BR	10+	216	20	1014.7	2-3	220	2-3	18.9	20.0	19.2
03	37°53.3'N	074°15.5'W	FAIR	BR	10	222	19	1014.2	2-3	220	2-3	19.0	20.3	19.0
04	37°53.2'N	074°15.5'W	CLR	BR	10	228	21	1013.8	2-3	220	2-3	18.9	20.3	18.8
05	37°53.6'N	074°15.3'W	FAIR	BR	10	220	16	1014.4	2-3	220	2-3	18.9	20	18.9
06	37°53.4'N	074°15.4'W	CLR	BR	10	227	14	1014.4	2	220	2-3	18.9	20	18.9
07	37°53.5'N	074°15.2'W	FEW	BR	10	225	16	1014.9	2	220	2-3	18.8	19.8	18.9
08	38°00.35N	074°14.17W	FEW	BR	10	215	18	1015.2	2	220	2-3	18.8	20.0	19.0
09	37°53.68N	074 15.63W	FEW ~~HZ~~	HZ	10	225	15.6	(inside) 1017.5	2-3	196	3	ENG 16.1	20.0	19.5
10	37°53.6'N	074° 15.3'N	FEW	HZ	10	223	15	1015.8	2-3	200	3	18.9	20.6	19.1
11	37°53.716"	074°15.88'W	FEW	HZ	10	225	16	SCS 1016.25	2-3	200	3	18.9	19.96	19.0
12	37°53.6'N	074°15.5'W	CLR	HZ	10	224	14	1015.5	1-2	190	2-3	19.1	20.6	19.4
13	37°53.7'N	074°15.2'W	CLR	BR	10+	224	13	1015.3	1-2	190	1-2	19.1	20.1	19.1
14	37°53.7'N	074°15.1'W	CLR	BR	10+	227	11.7	1015.1	1-2	190	2	19.0	20.9	19.1
15	3													
16	37°52.9'N	074°14.3'W	FEW	BR	10	230	13	1014.9	1-2	190	2-3	19.3	20.4	19.3
~~17~~														
18	37°41.8'N	074°29.3'W	FEW	BR	10	205	10	1015.6	1-2	210	1-2	19.2	20.1	19.3
19	37°39.0'N	074°33.0'W	FEW	-BR	10	245	5	1016.0	1-2	200	1-2	19.2	19.9	19.4
20	37°34.4'N	074°38.6'W	FEW	-BR	10	239	4	1016.6	1-2	200	1-2	19.1	20.0	19.7
21	37°29.2'N	074°44.5'W	FEW	-BR	10	202	7	1016.6	1-2	200	1-2	19.8	20.2	19.9
22	37°22.1'N	074°52.4'W	FEW	HZ	10	193	7	1017.1	1-2	200	1-2	19.8	20.2	19.9
23	37°15.1'N	075°00.0W	FEW	HZ	10	193	9	1017.0	1-2	200	1-2	19.8	20.6	20.2

SUPERSEDES NOAA Form 77-13D (3-76)

NOAA Form 57-11-13D
(10-12)

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

DECK LOG – WEATHER OBSERVATION SHEET

NOAA Ship	TIME ZONE	DAY OF WEEK	DATE (dd mmm yyyy)
THOMAS JEFFERSON S-222	+4	THURSDAY	20 OCT 2016

TIME	POSITION		SKY CONDITION	PRESENT WEATHER	VISIBILITY (nm)	WIND		SEA LEVEL Press. (mb)	SEA WAVE Height (ft)	SWELL WAVES		TEMPERATURE (°C)		
	LATITUDE	LONGITUDE				Dir. (true)	Speed (kts)			Dir. (true)	Height (ft)	SEA WATER	DRY BULB	WET BULB
00	37°07.0'N	075°08.0'W	CLR	NSW	10	203	11	1017.0	1-2	140	1-2	20.0	20.9	20.4
01	37°03.0'N	075°12.9'W	CLR	NSW	10	204	9.7	1017.0	1-2	190	1-2	19.9	21.1	20.5
02	37°02.0'N	075°18.5'W	CLR	NSW	10	198	10.2	1016.7	1-2	180	0-1	20.4	21.3	20.5
03	37°03.1'N	075°13.2'W	CLR	NSW	10+	195	10	1016.3	1-2	180	1-2	20.1	20.9	20.3
04	37°03.5'N	075°14.4'W	PC	NSW	10	192	12	1016.0	1-2	180	1-2	20.2	20.9	20.3
05	37°02.9'N	075°18.6'W	FAIR	NSW	10	190	10	1016.2	1-2	180	1-2	20.5	21.1	20.4
06	37°03.8'N	075°14.9'W	FAIR	-BR	~~10+~~ 10	180	11	1016.6	1-2	200	1-2	20.2	20.9	20.2
07	37°03.6'N	075°13.8'W	FEW	-BR	10	180	10	1016.6	<1	180	1-2	20.2	20.8	20.1
AK 08	37°03.0'N	075°16.9'W	CLR F	BR	10	179	12	1016.9	<1	180	1	20.2	21.3	20.3
09	37°02.03'N	075°19.6'W	CLR	BR	10	180	12	1017.3	<1	180	1-2	20.7	21.1	20.3
10	37°00.4'N	075°29.9'W	CLR	BR	10	185	13	1017.2	1	180	2	20.1	21.3	20.2
11														
12														
13														
14														
15	36°59.4	76°18.70	CLR	-BR	10									
16														
17														
18														
19														
20														
21														
22														
23														

SUPERSEDES NOAA Form 77-13D (3-76)

TJ Static Draft

G. Rice, E. Younkin
Hydrographic Systems and Technology Branch
2016-10-12

Introduction

With her very large fuel capacity, *Thomas Jefferson's* operational draft varies considerably over the course of a survey season. The draft of the reference point has historically been measured with a flexible water level sight tube. However, procedures for measuring and recording this value have not been well defined. To improve this process, a Sutron bubbler water level gauge was installed in 2014 to replace manual sight tube readings. In this report, we discuss the Sutron water level gauge and analyze data taken through gauge readings, draft mark readings and ellipsoidally referenced tide station data. We find all three systems of measurement to be acceptable, but the Sutron gauge provides the easiest and most precise measurement of static draft.

Manual Sutron and draft mark observations were made at 1140 and 1300 UTC and POS M/V data was recorded between these times. Through the use of the Autopoll software, one-minute interval Sutron data was also logged to a local computer. The Marinestar corrected POS MV data was processed in POSPac in forwards/backwards processing mode without the inclusion of base station data in order to generate an SBET. This SBET was used in the ellipsoidally referenced static draft script.

In this report, draft is defined as the distance from the reference point to the water surface with the positive direction down; when the reference point is above the water surface, as it typically is with *Jefferson* in all but her most heavily laden conditions, the draft will be a positive number. This is consistent with the sign conventions in both Caris and Kongsberg.

Vessel Sensitivity to Loading

By examining the ship stability tables, the weight of the survey launches, and typical fuel burns, we can calculate the vessel's sensitivity to loading. At her design draft, the stability book indicates 190.6 long tons per foot submergence, or 14,000 lbs/cm submergence. This means that an additional 14,000 lbs of deck loading will cause the ship to sink into the water by 1 cm. Conservatively estimating the full, laden weight of a launch at 18,000 lbs, the draft change from either deploying or recovering both launches is approximately 0.025 m. The typical daily fuel burn at survey speed (approximately 1600 gallons per day), will result in a draft change of less than 0.01 m per day or less than 0.06 m per week. Accordingly, we recommend updating the draft value in the HVF no more than once a week during survey operations.

Sutron Installation and Configuration

The Sutron bubbler water level gauge, similar to the NOAA field unit installed water level gauges, uses compressed gas to carry the static pressure at a submerged orifice to the pressure gauge in the instrument. This configuration allows the pressure sensor to be both dry and also be balanced against the atmospheric pressure such that variations in atmospheric pressure can be neglected in the determination of the water level head pressure. A photo of the sea-valve and orifice configuration is shown in Figure 1. With the vent valve open, the measured pressure is at the level of the orifice indicted by the arrow. This offset was measured by IMTEC in 2016 as 3.908 meters with respect to the IMU reference point [1]. With the vent valve closed, the effective orifice is the penetration in the shell plating. The offset to the shell plating was not accurately measured during the installation. In normal operations, the vent valve should be left open.

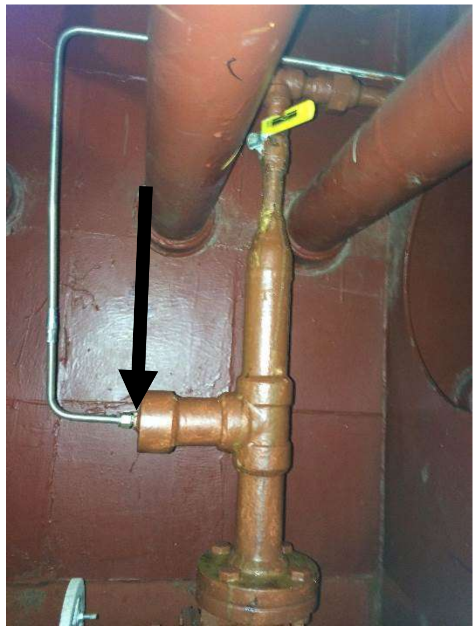


Figure 1: Bubbler gauge orifice and vent line. Vent valve has yellow handle and should be OPEN. Arrow indicated surveyed position of orifice and the location of the measured draft.

In general, conversion of a pressure measurement to a depth requires knowledge of the density of the water and the local gravitational attraction. The general equation of the height of the reference point above the water level is given below. This is the value (with correct sign) used in the 'waterline' section of the Caris HVF and in Kongsberg SIS.

$$wl = -PSI\,\frac{6894.7\,Pascal/psi}{\rho * g} - orificeZ \qquad (1)$$

where *wl* is the height of the reference point above the waterline, ρ is water density in kilograms/meter^3, g is the acceleration due to gravity, and *orificeZ* is the surveyed distance from the reference point to the bubbler orifice. The gravitational acceleration, 9.79819 m/s^2, was calculated from the WGS84 Gravity Model for latitude 36. For these small depths, the effect of the variability of gravity is negligible, accounting for an effective draft error of less than 0.01 m for latitude changes between 0 and 60 degrees. The density effect is more significant, with a variation from fresh to salt water yielding a difference of approximately 0.08 m for this system. Using typical sea-surface water density of 1024 kg/m^3, the formula for the height of the reference point above the water line is given by:

$$wl = -0.68718(\mathrm{PSI}) + 3.908 \qquad (2)$$

These figures have been entered into the custom fields of the bubbler gauge (station setup/ accubar setup/ accubar settings/ user slope and user offset) such that the output value is the meters of the reference point above the waterline (note that when the ship is fully laden, the reference point may be below the water line and this number will then be negative).

On April 17, 2015 (Dn107) a series of six water level measurements were made from the IMU to the level in a sight tube. A laser was set on the top of the IMU and a ruler used to measure the distance from the top of the IMU to the water level in the sight tube. The reading was corrected for the height of the laser. The water level was 0.285 ± 0.004 meters relative to the reference point. That afternoon, a CTD cast measured a density of 1012 kg/m^3 in the brackish waters of the Elizabeth River. Using this density, the observed pressure of 5.182 psi on the bubbler gauge, and equation (2) above, the bubbler derived waterline height is 0.305 meters, yielding an error of 0.02 m. The source of this error is unknown, but is within tolerance for hydrographic survey work.

Unless extended survey operations are planned for fresh waters (e.g. the Great Lakes), we recommend the standard density of 1024 kg/m^3 be used for the calculation of waterline and the custom offsets retained as entered. In brackish waters, the reported draft variation with density may be significant enough to consider for precise calibration work, though can likely be neglected for routine survey work. In the case were additional precision is required, we recommend calculating the waterline from the observed pressure and observed density using equation (1) to derive the height.

Sutron Results

Readings were taken from the Sutron at the beginning and end of observations at 0.385 meters and 0.351 meters respectively. The readings were also recorded via AutoPoll every minute into CSV files and displayed in Figure 2. Again, these readings are the water level relative to the IMU as the bubble gauge offset from the IMU, 3.908 meters, was entered into the Sutron. The mean of this time series is 0.37 meters with 0.02 at two standard deviations.

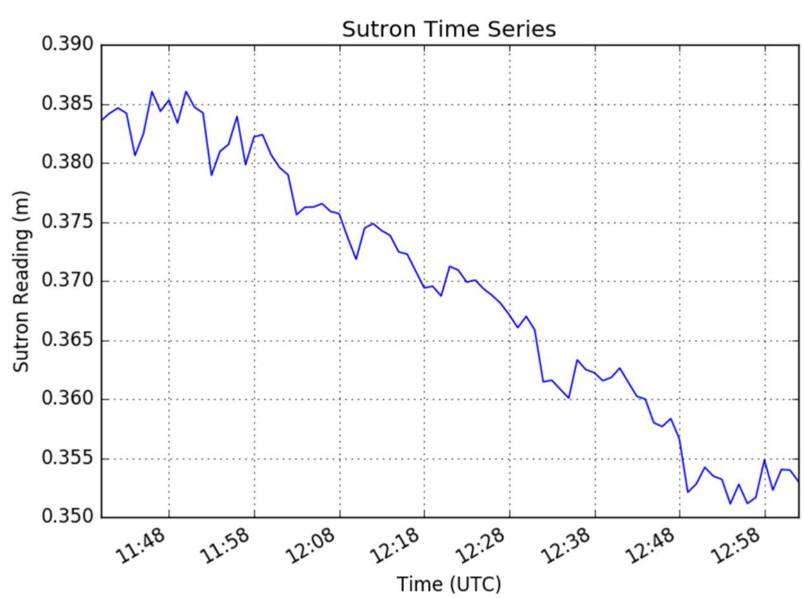


Figure 2 - The Sutron time series.

There is a clear trend in the Sutron data. When an extended time series is plotted it appears that the static draft test was conducted during an inopportune time as displayed in Figure 3. After discussing this anomaly with the ship, we learned that ballast was taken on at approximately 1100 UTC to achieve an additional few inches of draft astern. We can see that a change of about 3.5cm was seen in the Sutron derived waterline value. Using the previously mentioned 14,000 lbs/cm loading estimate, we can say that about 49,000 lbs or about 21.71 cubic meters of sea water was taken on during this period.

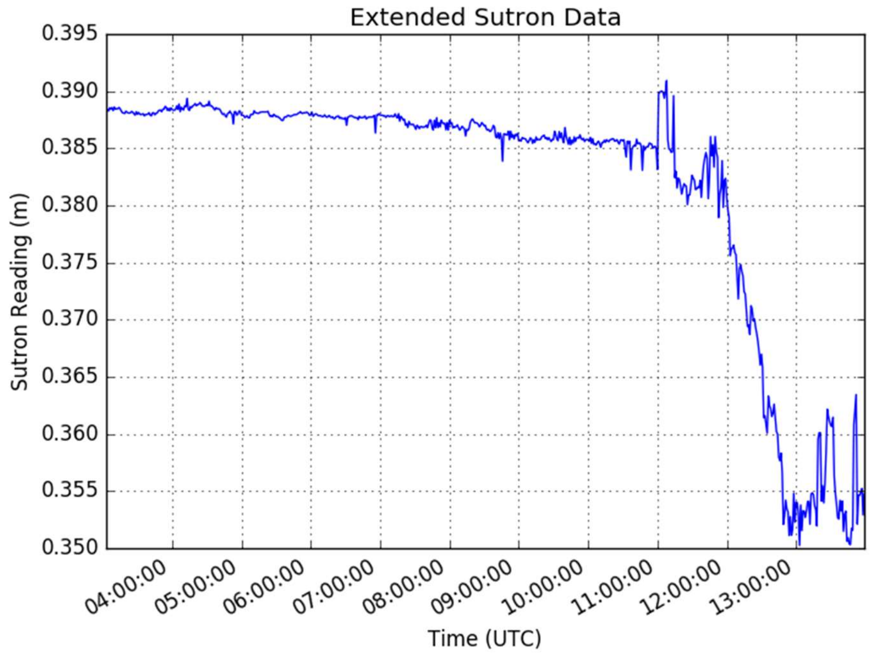


Figure 3 – The Sutron time series from 2016-10-12 for a period before and after the static draft test.

Draft Mark Results

The transom and bow (port side) draft marks were observed from the wharf at the times described. The draft did not change at an observable amount over this time, with the transom reading 13.9 feet and the bow (port side) reading 13.8 feet. This finding, along with our internal understanding of the accuracy of draft mark readings, led to our assumed two standard deviation of 0.07 cm. A weighted average was used to estimate the draft at the horizontal location of the IMU, which is closer to the bow. This average, 13.83 feet, was then converted to meters and referenced to the IMU using an IMU to keel offset derived from the raw survey values from the ship offset survey conducted in August of 2016 [1]. This offset was derived by averaging the keel vertical offset observations after the values were referenced to the IMU, with a result of 4.56 meters. The final result, 0.34 meters, with this derivation from the draft marks is shown in Table 1.

Table 1 - Draft of the reference point from draft mark readings

TJ Static Draft	
	Reading (Feet)
Bow - PORT	13.8
Transom	13.9
Average Reading (Feet) at estimated reference point	13.83
Average Reading (Meters) at estimated reference point	4.22
Approximate Standard Deviation (2 sigma)	0.07
IMU to Keel offset	4.556
Waterline relative to the IMU (RP)	0.336

Ellipsoid Referenced Static Draft Results

A POS MV file was recorded during the time period described and processed in POSPac using forwards/backwards processing without the inclusion of any base station data. While some attempt was made to understand the waterline offset from the AutoQC tool in Pydro, eventually the ERSD script, also in Pydro, was used instead. This approach results in a poorer tide correction since the phase and amplitude at the Atlantic Marine Operations Center from the local tide gauges is not taken into account. The script was run twice, once for the Money Point tide gauge, 8639348, and again for the Sewell's Point tide gauge, 8639610.

The ERSD script references the water levels to the ellipsoid using a provided offset from the water level data to the ellipsoid. The water levels are then subtracted from the ellipsoid height of the ship, with the resulting value being the reference point draft over time. These values are then averaged for a final estimate. More information on the ERSD script can be found in [2].

The Money Point gauge reference resulted in a mean draft of 0.43 meters with two standard deviations being 0.07 meters as reported by the script in Figure 4. The offset from mean lower low water to WGS84 provided by VDatum for the Money Point gauge was -39.0014 meters.

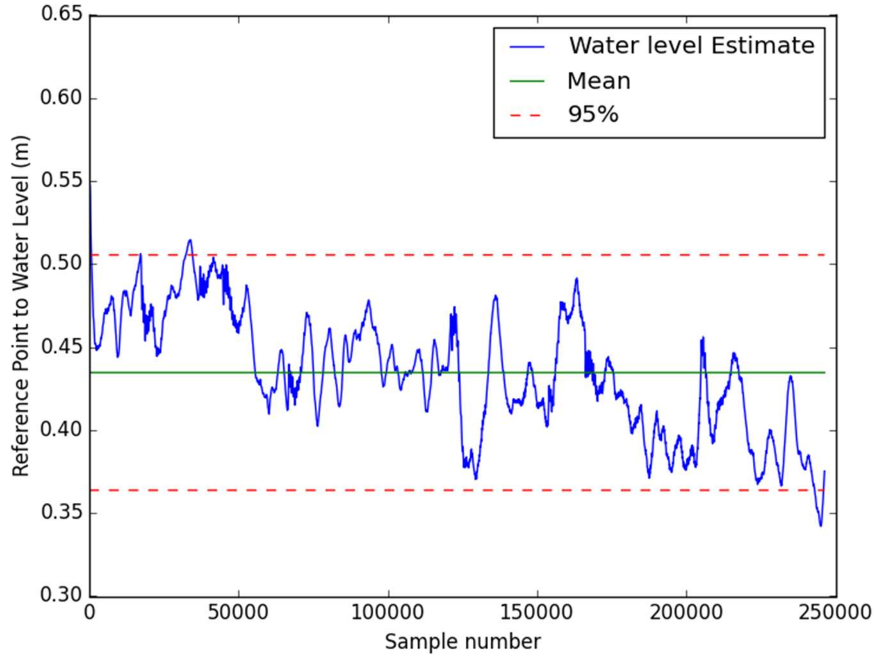


Figure 4 - SBET values relative to the ellipsoid referenced water levels from Money Point over the time period.

The Sewell's Point gauge reference resulted in a mean draft of 0.32 meters with two standard deviations being 0.08 meters as reported by the script in Figure 5. The offset from mean lower low water to WGS84 provided by VDatum for the Sewell's Point gauge was -38.7367 meters.

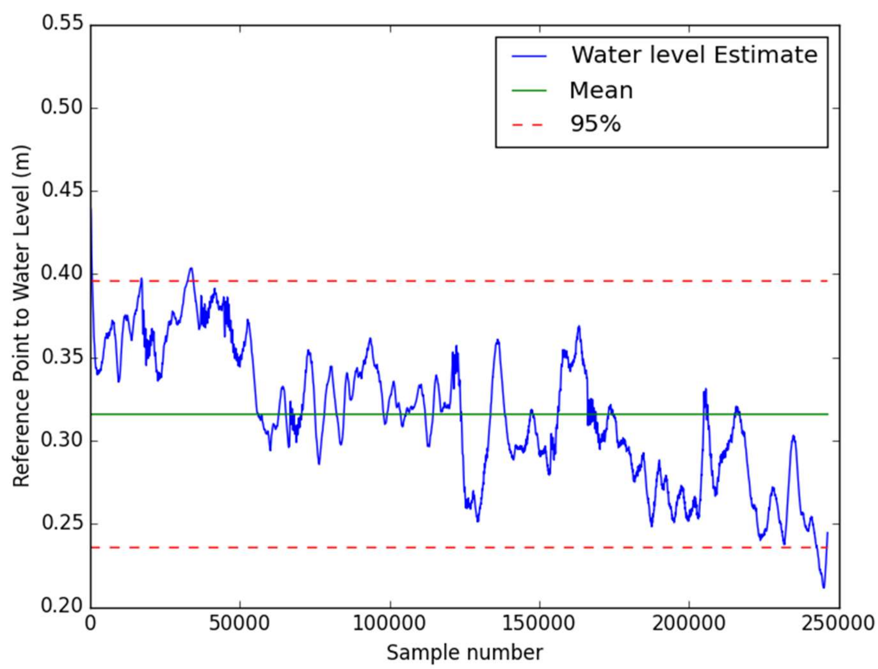


Figure 5 - SBET values relative to the ellipsoid referenced water levels from Sewell's Point over the time period.

Conclusion

The draft of the reference point from the different approaches is summarized in Table 2.

Table 2 – A summary of the static draft estimates.

Source	Result (Meters)	2 Standard Deviations (Meters)
Draft Readings	0.34	0.07
Sutron	0.37	0.02
ERSD – Money Point	0.43	0.07
ERSD – Sewell's Point	0.32	0.08

No final value is derived as the static water level changes with loading conditions. Instead this series of tests confirms that each method arrives at a statistically equivalent value, and any of them could be used. That being said, only the ERSD and Sutron method are precise enough to even see the 3.5cm change in draft during the testing period. This is to be expected, as that frequency and precision of both POS MV and tide gauge measurements far surpasses the draft readings and that change was well within the variability of the draft reading measurement. For its simplicity and precision, the Sutron gauge is the recommended method for estimating the ship's static water level. The Sutron should only be used when the ship is dead in the water as water flowing over the hull will affect the measurement.

References

[1] "NOAA Thomas Jefferson (S 222) Sensor Alignment & Orthogonal Coordinate Survey July-August 2016, Rev 1," The IMEC Group, Ltd, 2016

[2] G. Rice, "Estimating Vessel Static Waterline Using Vessel Ellipsoid Height," NOAA Office of Coast Survey, Silver Spring, MD, Tech Rep. 2011

NOAA Ship Thomas Jefferson CARIS HIPS 9.1 Post Processing Workflow for the EM2040

HSTB, December 7, 2016

Purpose

NOAA Ship *Thomas Jefferson's* survey system is configured differently than other Kongsberg systems in the NOAA hydrographic fleet. Most notably, the primary reference point for the survey system is placed at the IMU rather than the multibeam transmit transducer because *Thomas Jefferson* has two multibeam systems; one POS MV configuration works for both. Also of note, *Thomas Jefferson* has a MarineStar license and can thereby use the ellipsoid height stored in the Kongsberg data directly without the need for POSPac post processing.

Because of how the reference point- transmitter lever arm is accounted for in Caris, there is no one HVF and processing configuration that can accommodate the various possible processing paths (e.g. using real-time Marinestar height and SIS raytracing to convert and merge in Caris without sound velocity correction (SVC), applying delayed heave and a new sound speed profile in Caris and using a tide corrector, etc.). Each of these processing paths can be accommodated, but many require different HVF configurations and processing parameters. Please contact HSTB for additional details if interested.

The recommended workflow options below have been formulated and tested by HSTB. While the required steps making up each method may be less efficient than possible for a given approach, this affords the most flexibility for data processing under one HVF. ***This HVF is named S222_EM2040_HSTB.hvf***.

The methods require application of the POS M/V TrueHeave (delayed heave) data and requires computing the SVC in CARIS HIPS; the latter is mandatory regardless of whether new sound speed information or calculations beyond that used in Kongsberg SIS data acquisition are available or desired. Specifically, these steps are required for both the real-time ellipsoid-referenced survey (ERS) processing method and the traditional water levels processing method, as detailed below.

Method

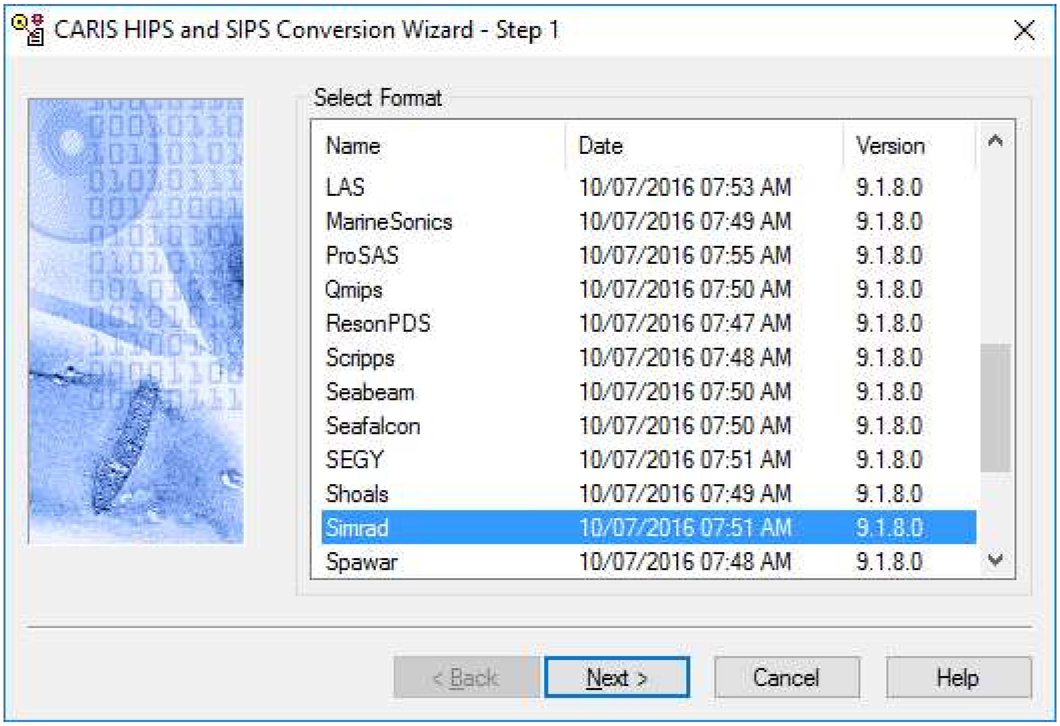
The two methods are as follows:

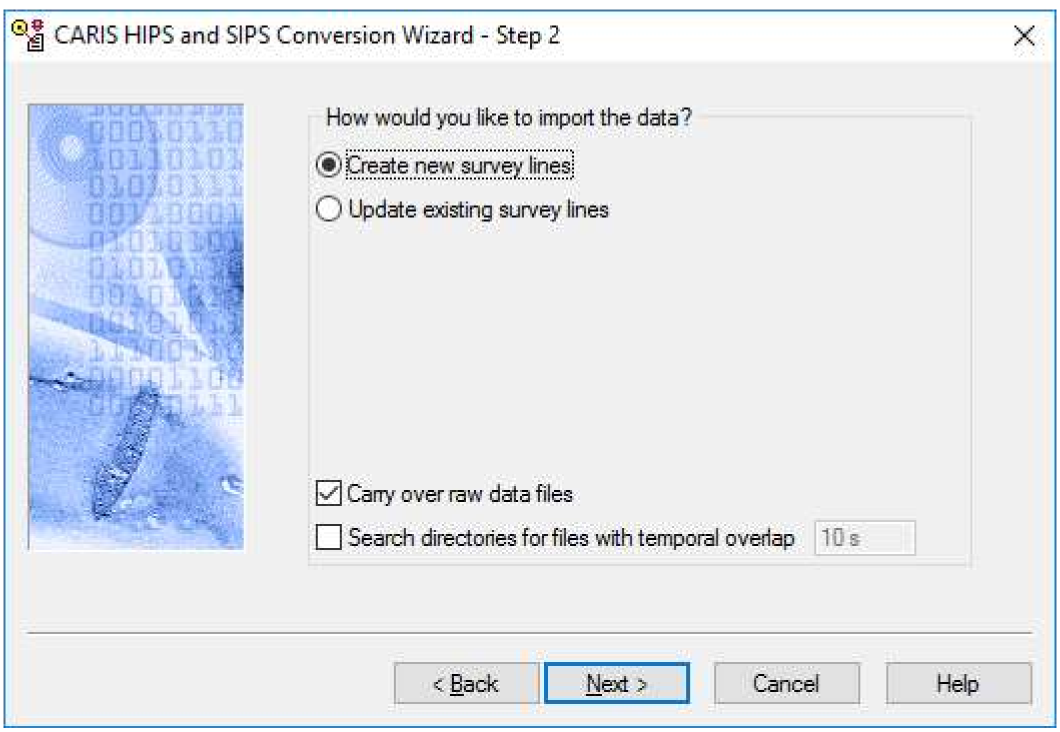
1) ERS
    a. Convert MBES data → Load Delayed Heave → Sound Velocity Correct → Compute GPS Tides → Merge with GPS Tides → TPU

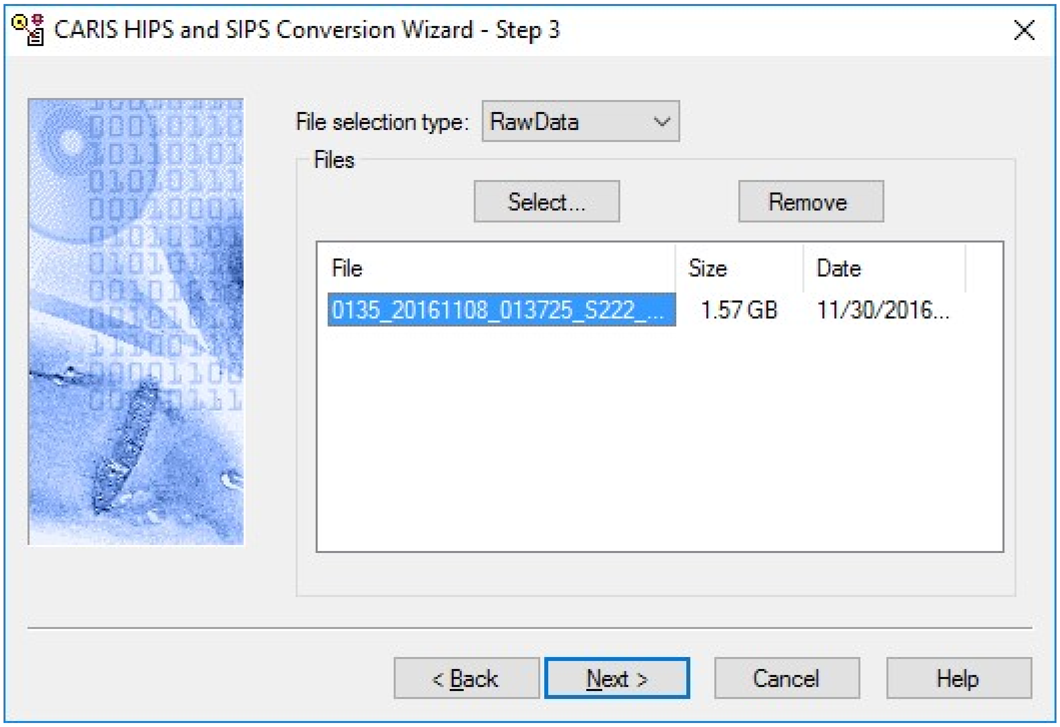
2) Traditional Water Levels
    a. Convert MBES data → Load Delayed Heave → Load Tides → Sound Velocity Correct → Merge → TPU

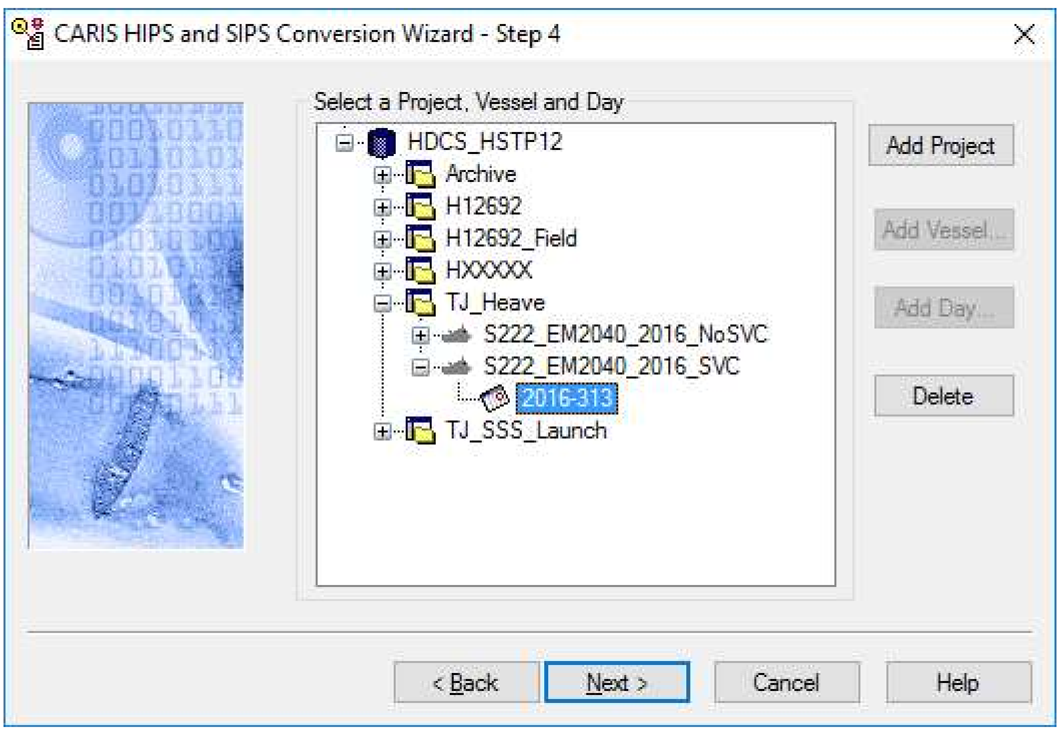
Procedure

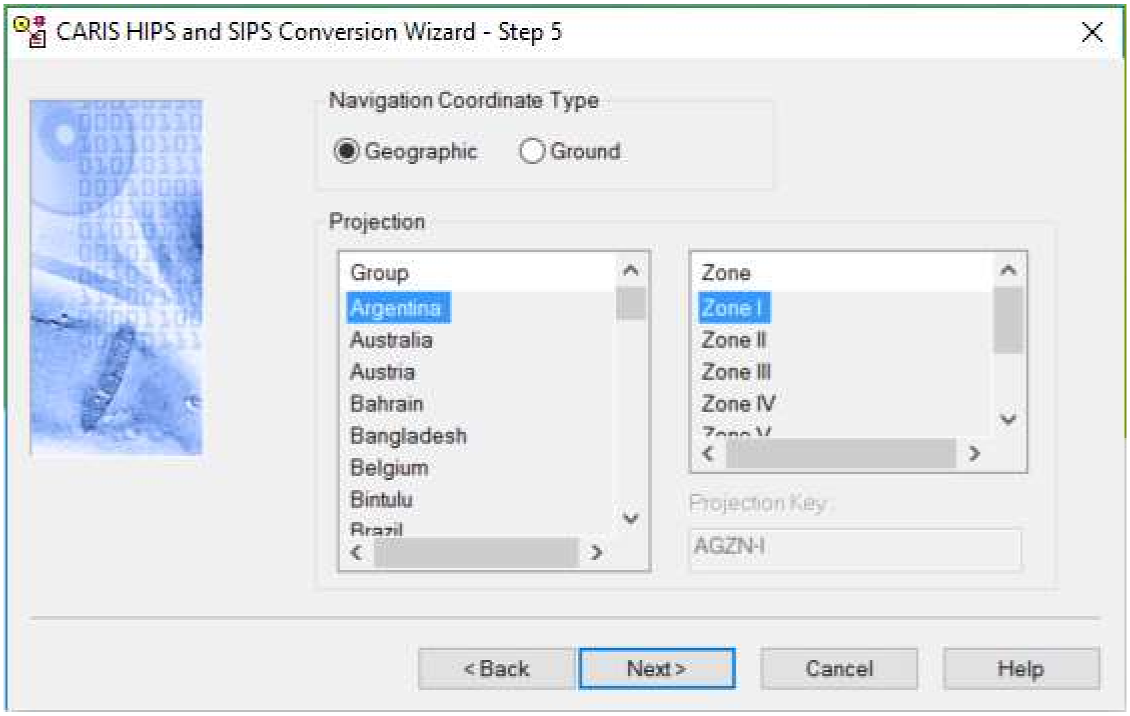
Conversion (both methods, 1 and 2)

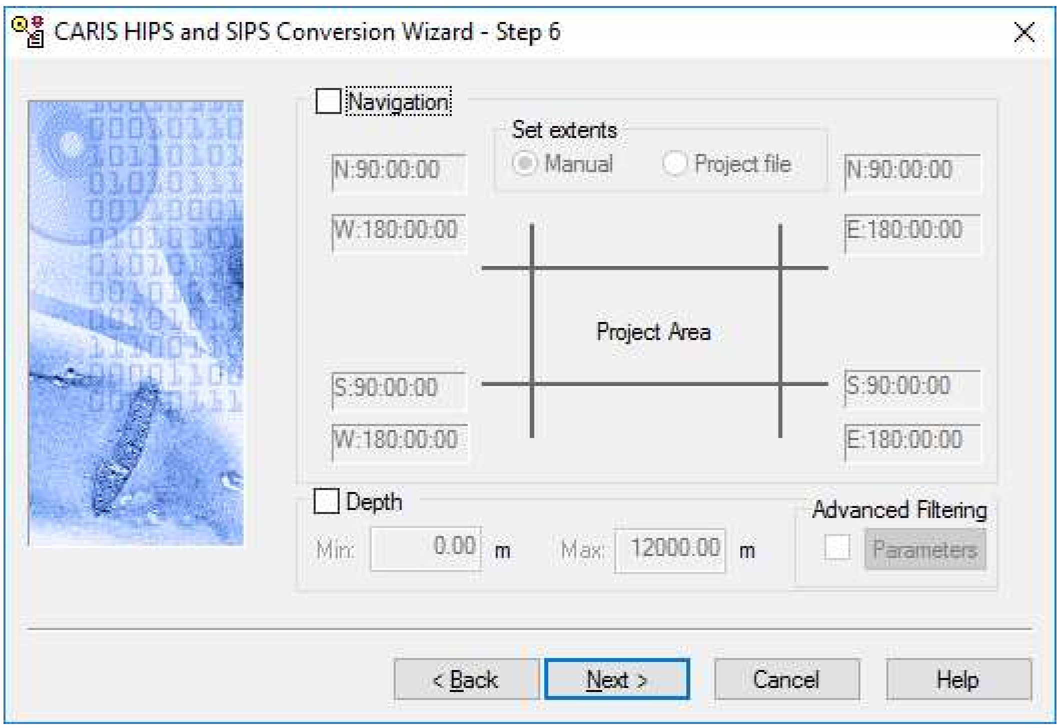




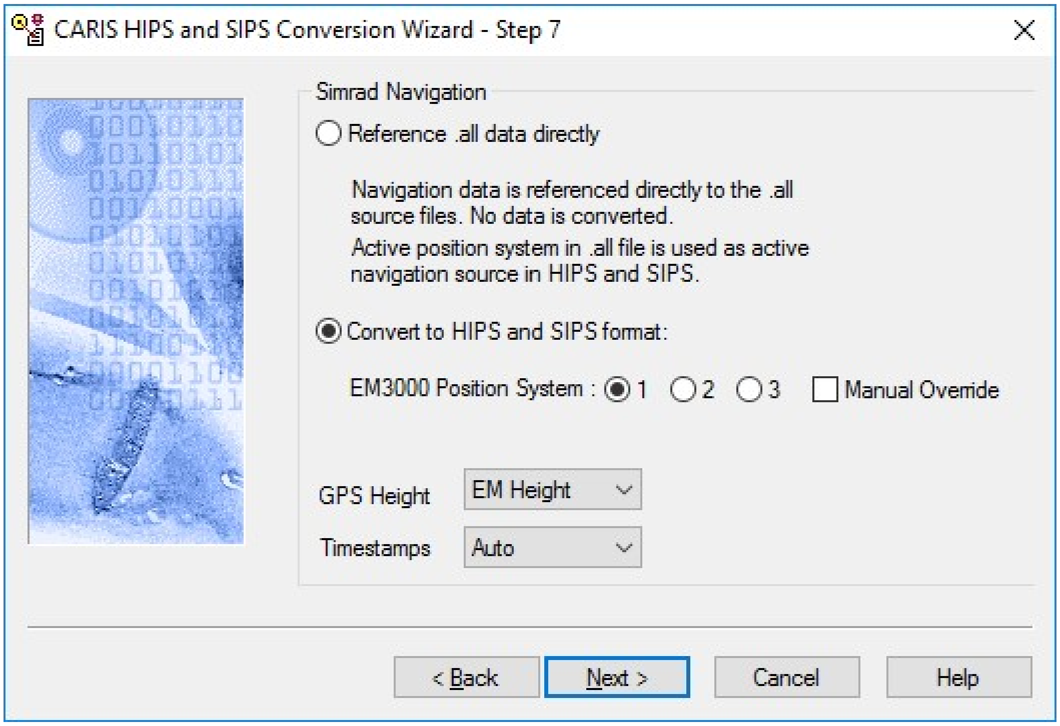

CARIS HIPS and SIPS Conversion Wizard - Step 3
File selection type:
RawData
Files
Select...
Remove
File
Size
Date
0135_20161108_013725_S222_...
1.57 GB
11/30/2016...
< Back
Next >
Cancel
Help

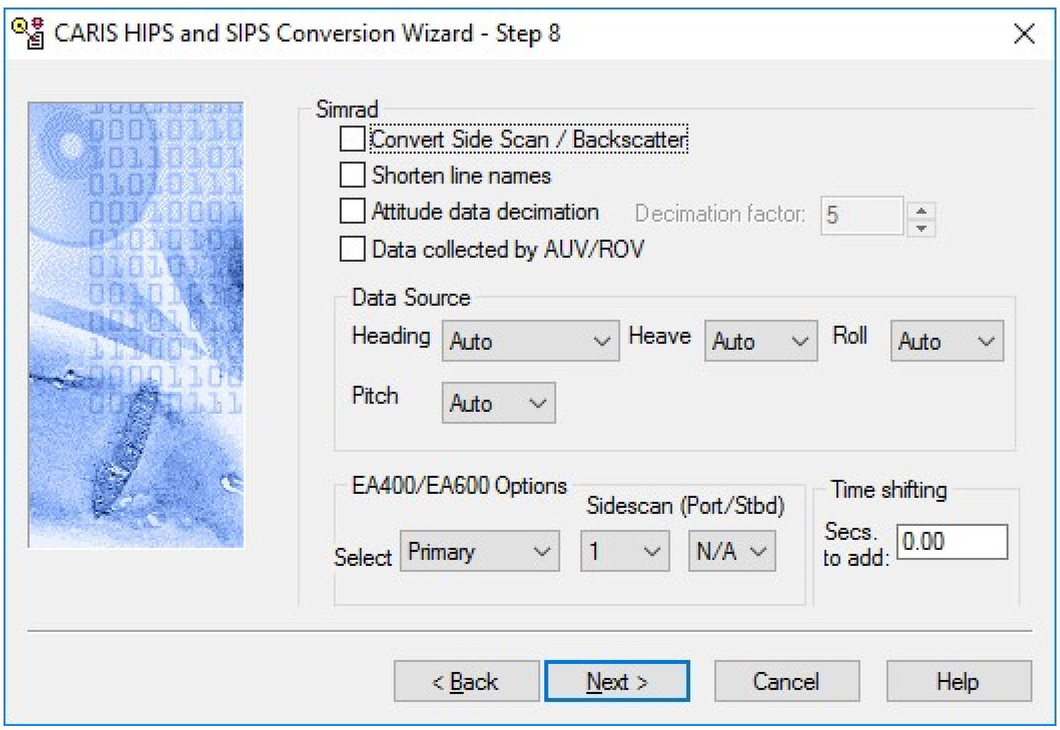

CARIS HIPS and SIPS Conversion Wizard - Step 4
Select a Project, Vessel and Day
HDCS_HSTP12
Archive
H12692
H12692_Field
HXXXXX
TJ_Heave
S222_EM2040_2016_NoSVC
S222_EM2040_2016_SVC
2016-313
TJ_SSS_Launch
Add Project
Add Vessel...
Add Day...
Delete
< Back
Next >
Cancel
Help

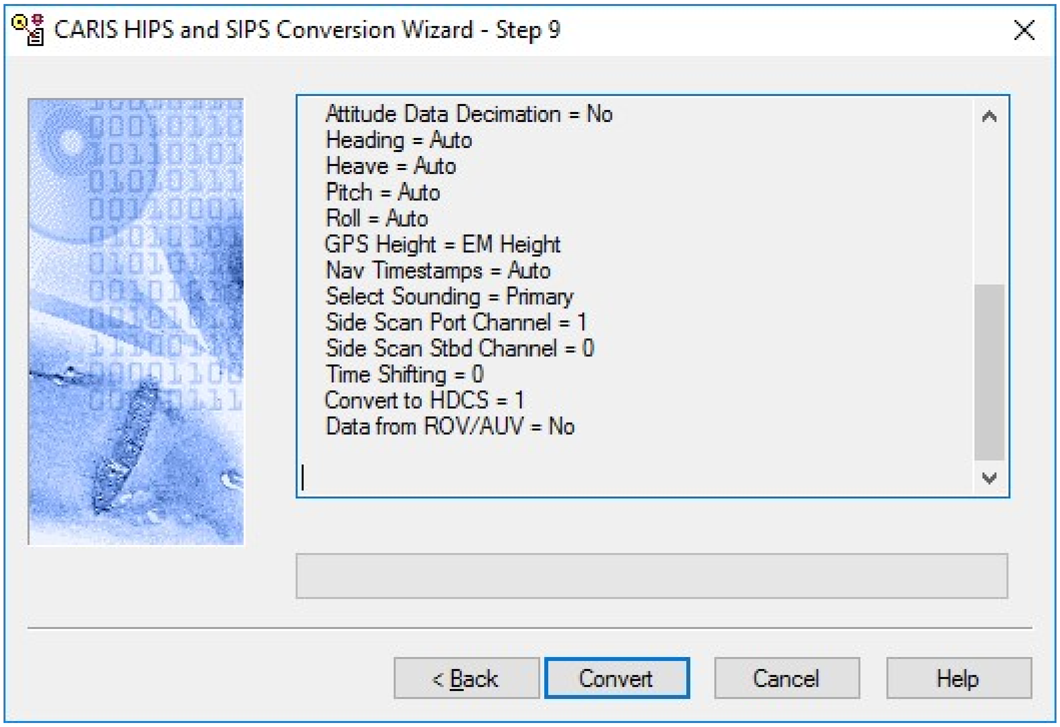

CARIS HIPS and SIPS Conversion Wizard - Step 5
Navigation Coordinate Type
Geographic
Ground
Projection
Group
Argentina
Australia
Austria
Bahrain
Bangladesh
Belgium
Bintulu
Zone
Zone I
Zone II
Zone III
Zone IV
Projection Key
AGZN-I
< Back
Next >
Cancel
Help


CARIS HIPS and SIPS Conversion Wizard - Step 6
Navigation
Set extents
Manual
Project file
N:90:00:00
W:180:00:00
N:90:00:00
E:180:00:00
Project Area
S:90:00:00
W:180:00:00
S:90:00:00
E:180:00:00
Depth
Min: 0.00 m
Max: 12000.00 m
Advanced Filtering
Parameters
< Back
Next >
Cancel
Help

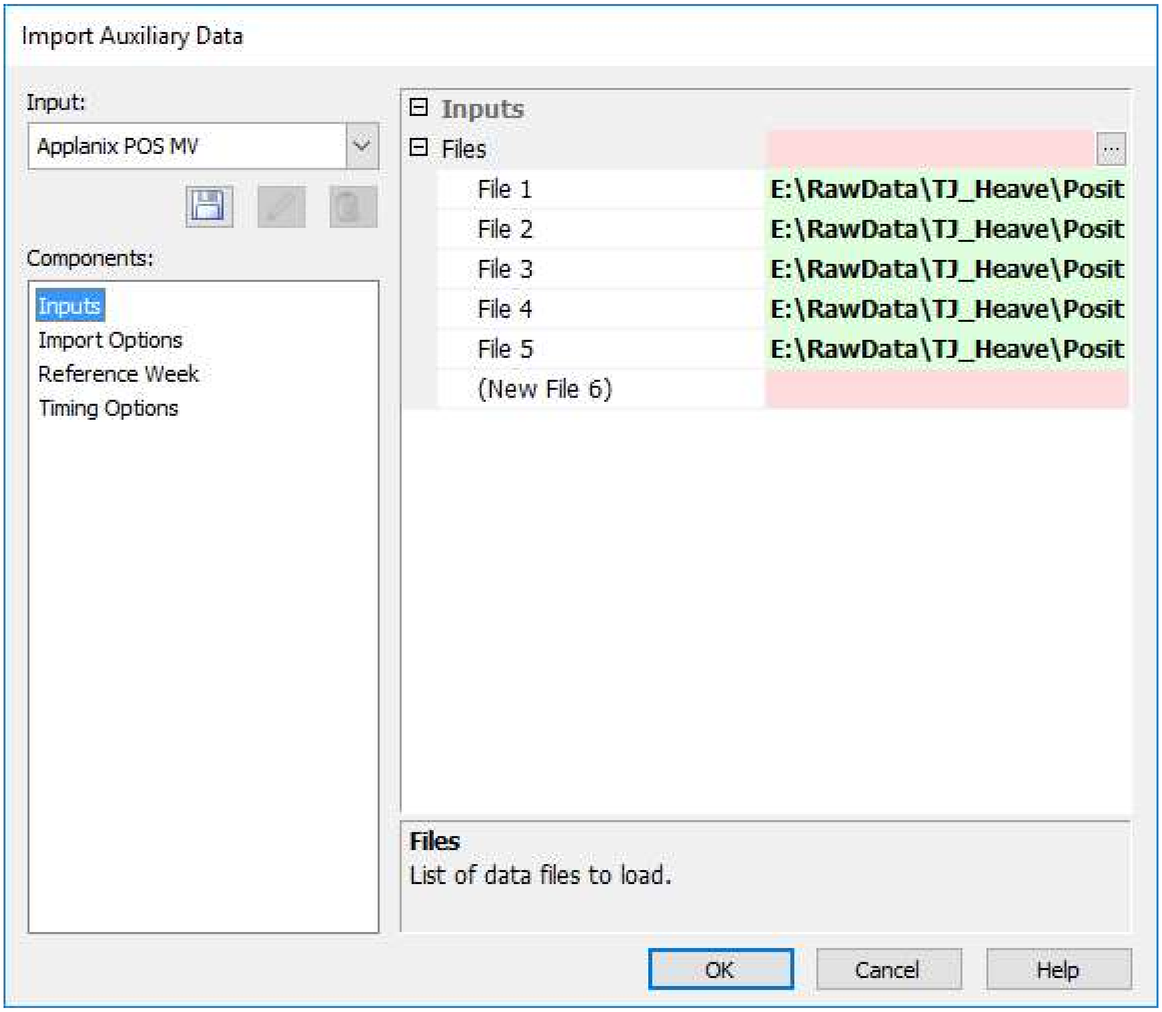
Data sources are set to “Auto” in the following dialogues because CARIS conversion algorithms are capable of reading the .all file (and other file types; ie: hsx) and determining data source.

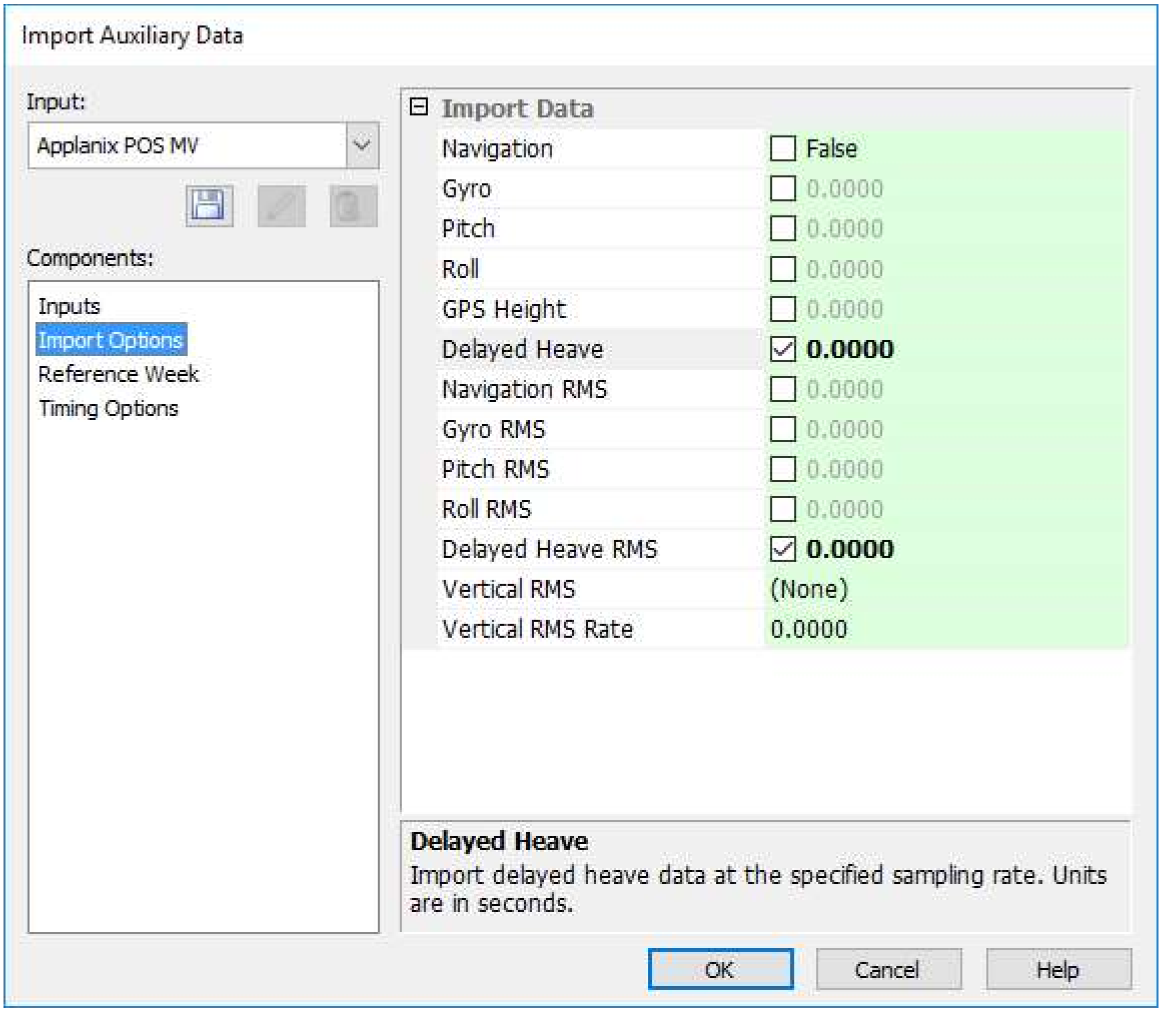


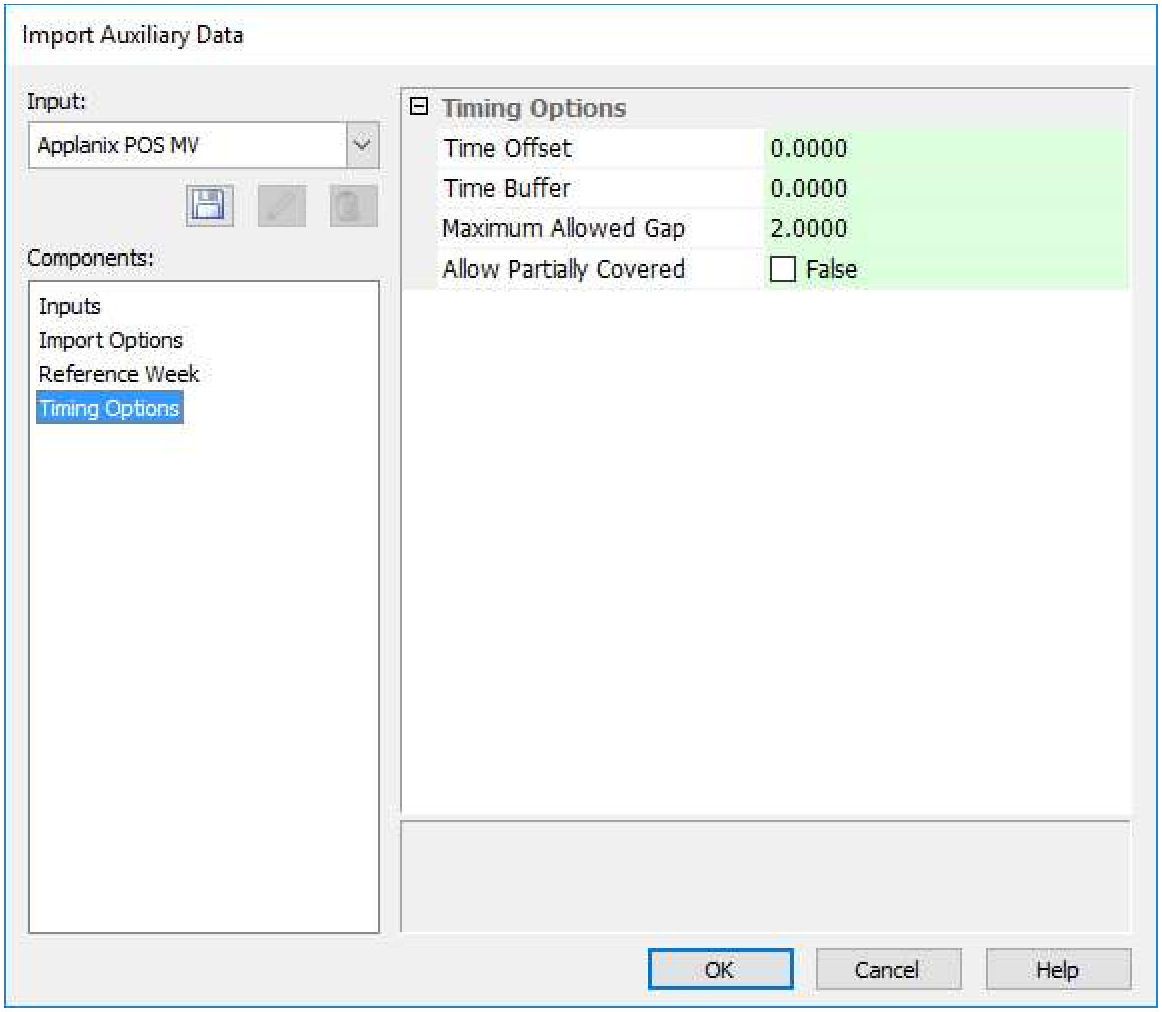



CARIS HIPS and SIPS Conversion Wizard - Step 9
Attitude Data Decimation = No
Heading = Auto
Heave = Auto
Pitch = Auto
Roll = Auto
GPS Height = EM Height
Nav Timestamps = Auto
Select Sounding = Primary
Side Scan Port Channel = 1
Side Scan Stbd Channel = 0
Time Shifting = 0
Convert to HDCS = 1
Data from ROV/AUV = No
< Back
Convert
Cancel
Help

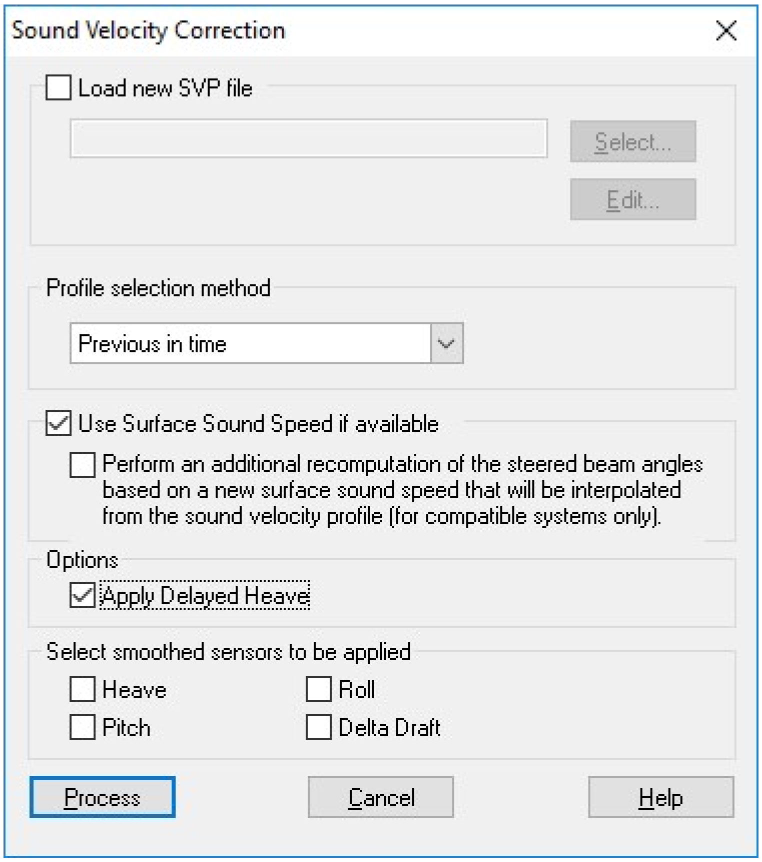
Import Delayed Heave (both methods, 1 and 2)




Import Auxiliary Data
Input:
Applanix POS MV
Components:
Inputs
Import Options
Reference Week
Timing Options
Import Data
Navigation
False
Gyro
0.0000
Pitch
0.0000
Roll
0.0000
GPS Height
0.0000
Delayed Heave
0.0000
Navigation RMS
0.0000
Gyro RMS
0.0000
Pitch RMS
0.0000
Roll RMS
0.0000
Delayed Heave RMS
0.0000
Vertical RMS
(None)
Vertical RMS Rate
0.0000
Delayed Heave
Import delayed heave data at the specified sampling rate. Units are in seconds.
OK
Cancel
Help


Import Auxiliary Data
Input:
Applanix POS MV
Components:
Inputs
Import Options
Reference Week
Timing Options
Timing Options
Time Offset
0.0000
Time Buffer
0.0000
Maximum Allowed Gap
2.0000
Allow Partially Covered
False
OK
Cancel
Help

While a new sound speed profile does not need to be added in this step, the SVC step is required for these workflows. By leaving the "Load new SVP file" box unchecked, CARIS will use the SV profiles embedded in the raw data per the .all file. Apply Delayed Heave is selected so that lever arm corrections are performed accurately. If Delayed Heave is not selected in this step, then a heave artifact will be introduced in the processed data.



GPS Tides is a method for computing the ellipsoid height of the vessel such that the bathymetry can be referenced to the ellipsoid. SVC'd depths are compensated for motion and are relative to the static water level. Because the converted vessel GPS Height (Kongsberg ,all EM Height) includes the water line offset and motion, in Compute GPS Tide we answer: *False* to Water Line, but apply=*True* to both the Dynamic Draft (to match the HVF) and the Dynamic Heave (Delayed Heave). The following list summarizes the options accounting required in Compute GPS Tides for the Thomas Jefferson EM2040.

-Smooth GPS height is not selected because we want to use the observed GPS Height.

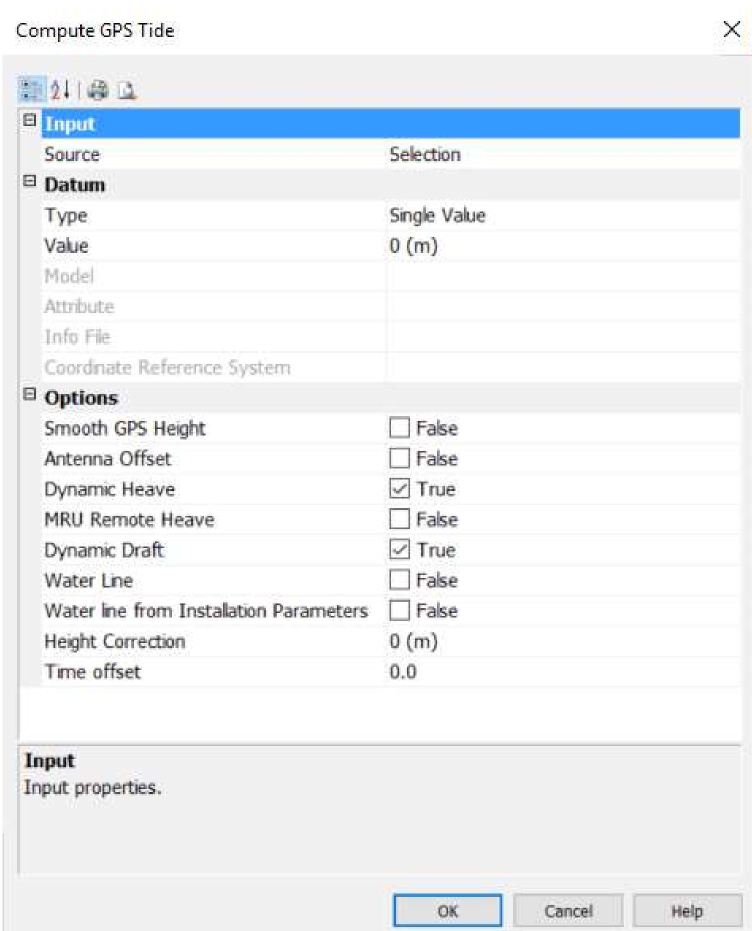
- Antenna offset is not selected because offsets from GPS antennas to the IMU accounted for in POS M/V

-Dynamic Heave is applied in order to remove heave from the observed GPS Height, smoothing the time series the same way that accounting for heave smooths the bathymetry.

-SIS is not accounting for lever arm offsets to the transducer from IMU with the GPS height, so the GPS Height is at the IMU as is Delayed Heave in the POS M/V file. Thus MRU Remote Heave is not selected because our RP is the IMU; moment arms are identically zero.

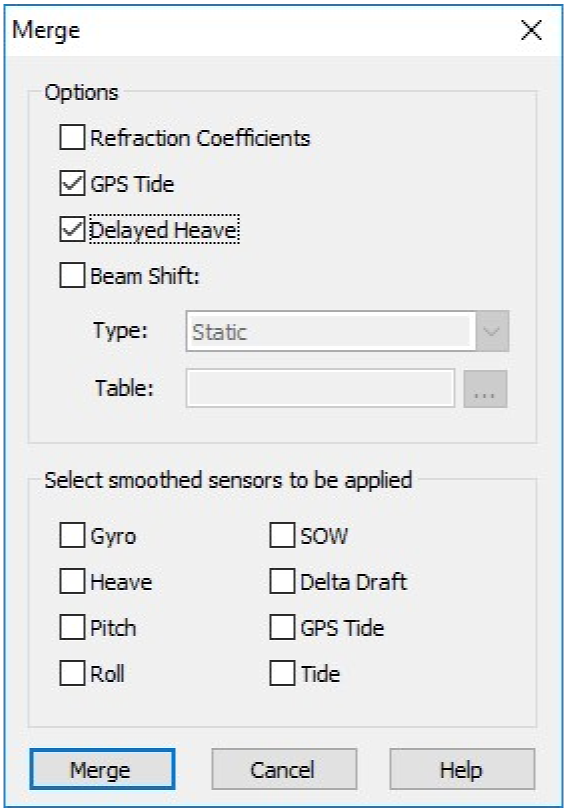
-Dynamic Draft (DD) is selected for congruence with HVF; DD is applied to the bathymetry per the HVF, so the GPS Height must be compensated to match.

-The dynamic GPS Height values in the .all file (EM Height, per conversion) are offset from the IMU by the water line as defined in SIS. Waterline is not applied because the SVC'd depths account for the waterline, per introductory paragraph in this section.

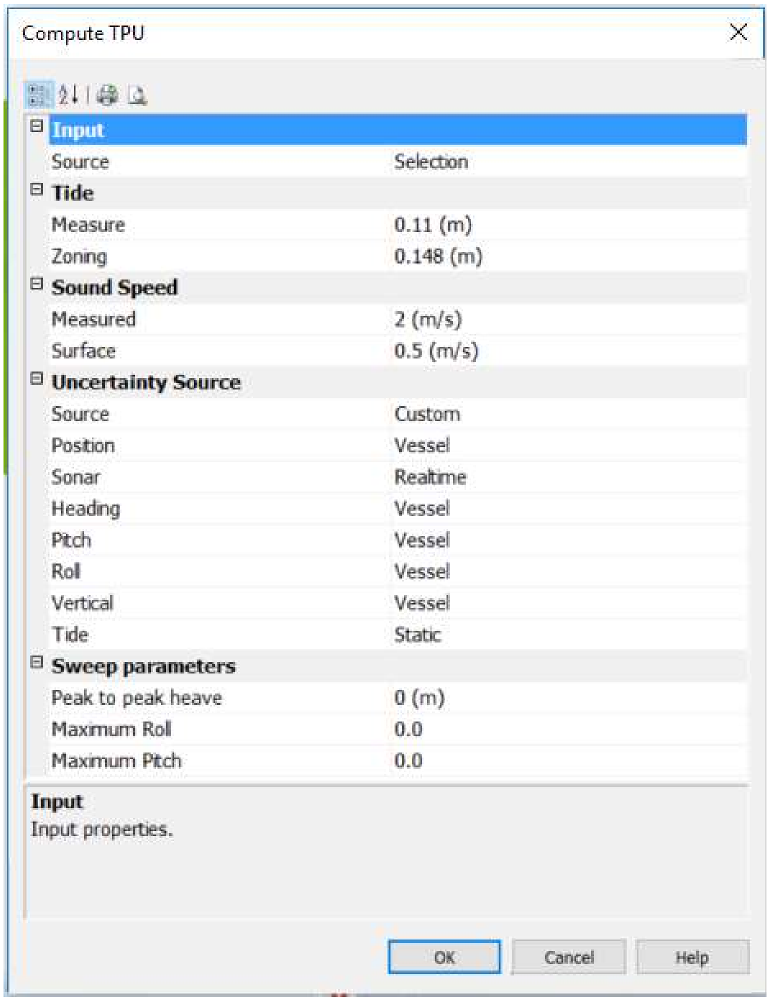


Merge and Compute TPU - Method 1 (ERS)

Calculates the final position for soundings based on observed depths and applied corrections in post-processing. Select GPS Tides because this is an ERS processing method, and Delayed Heave as needed to match our application of the same in during our *mandatory* SVC, described above.

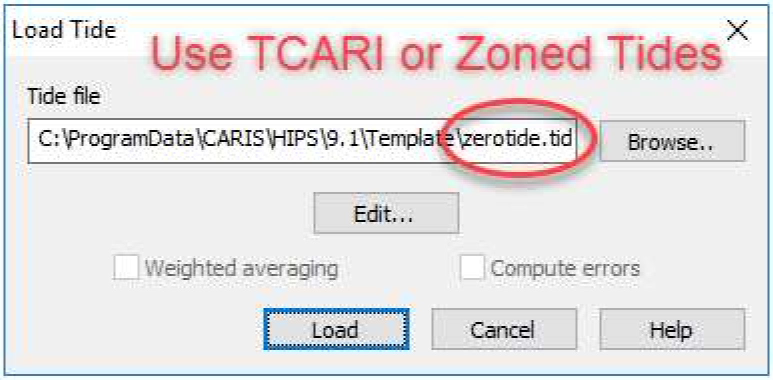


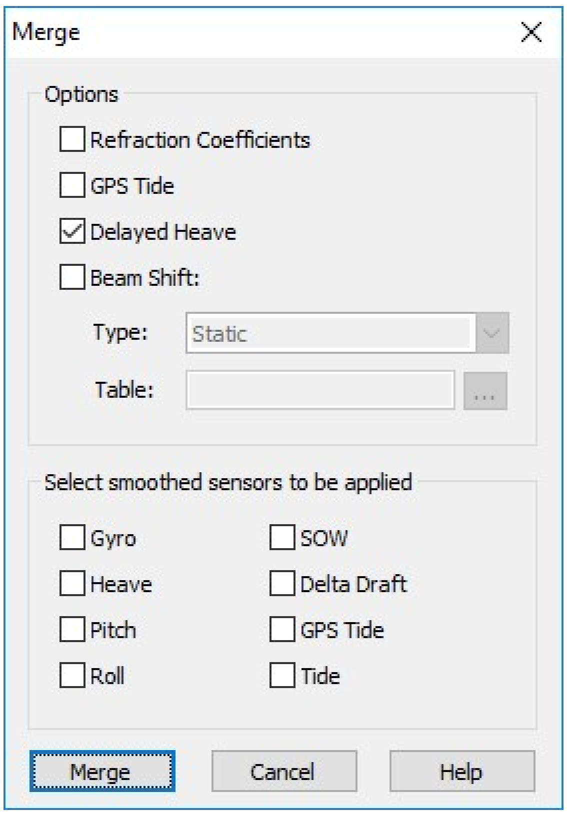
TPU for the vertical datum when surveying to the ellipsoid is a variance summation of the uncertainties associated with (1) MarineStar-aided POS MV height and (2) the datum separation (SEP) model. The MarineStar uncertainty is placed in the Tide / Measured section of the TPU dialog as 0.11 meters. The SEPuncertainty is placed in the Tide / Zoning section of the TPU dialog and is survey area-specific as provided in Project Instructions (e.g., for OPR-G329-TJ-16/17, VDatum SEP StdDev=0.148m). Sonar uncertainty is per the converted Realtime Kongsberg metrics from the .all. All other uncertainty sources are set to zeros via the HVF; see the Method 2 – Traditional Water Levels Compute TPU section for more information regarding this.



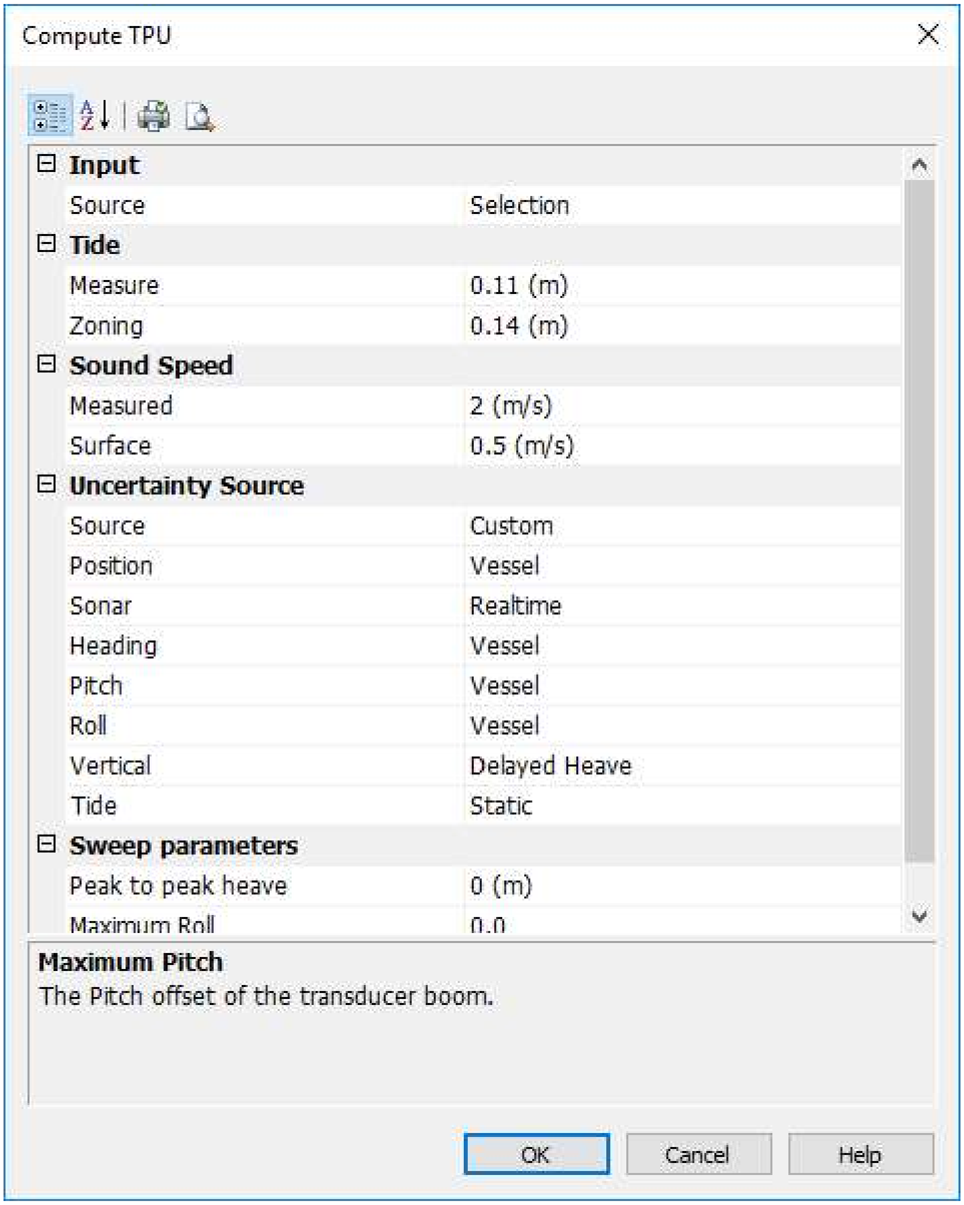
====== ComputeTPU start: Dec 7, 2016 8:00:36 AM ======
E:\ProcData\HDCS_Data\TJ_Heave\S222_EM2040_2016_SVC\2016-313\0135_20161108_013725_S222_EM2040. The following error sources were applied:
Warning: Realtime gyro errors not available. Vessel settings used instead.
Warning: Realtime pitch errors not available. Vessel settings used instead.
Warning: Realtime roll errors not available. Vessel settings used instead.
Warning: Realtime position errors not available. Vessel settings used instead.
Warning: Realtime tide errors not available. Static values used instead.
Sonar: Realtime data
Position: Vessel settings
Gyro: Vessel settings
Heave: Realtime Delayed Heave
Pitch: Vessel settings
Roll: Vessel settings
Tide: Static values
====== ComputeTPU end: Dec 7, 2016 8:00:57 AM (Elapsed Time: 00:00:21) ======

Load Tide, Merge and Compute TPU - Method 2 (Traditional Water Level Corrections)





Normal practice in the traditional water level method is to enter the uncertainty values attributed to vessel speed (0.03m), loading (0.06m), draft (0.03m), and delta draft (0.05m) in the HVF TPU StdDev, for Compute TPU Uncertainty Source = Vessel look-up. Our workflow sets them to zero in the HVF to account for our preference for one HVF for both non-ERS and ERS processing. For the Method 2 (Traditional Water Levels) we instead account for the aforementioned components as a single variance summation (root sum square; RSS=0.09m) and place that in the "Tide / Measured" slot. The actual (total) tide error component as provided in section 1.3.3 of the Project Instructions is placed in the Tide / Measured value (e.g., for OPR-G329-TJ-16/17, ZDF Tides StdDev = 0.10m). For TCARI-based projects, an average uncertainty value will be provided in the PI as well (e.g., OPR-E350-TJ-16, TCARI mean StdDev = 0.07m; OPR-D302-TJ-16, TCARI mean StdDev = 0.22m).



====== ComputeTPU start: Dec 7, 2016 8:30:55 AM ======
E:\ProcData\HDCS_Data\TJ_Heave\S222_EM2040_2016_SVC\2016-314\0135_20161108_013725_S222_EM2040. The following error sources were applied:
Warning: Realtime tide errors not available. Static values used instead.

Sonar: Realtime data
Position: Realtime data
Gyro: Realtime data
Heave: Realtime Delayed Heave
Pitch: Realtime data
Roll: Realtime data
Tide: Static values

====== ComputeTPU end: Dec 7, 2016 8:31:17 AM (Elapsed Time: 00:00:21) ======

NOAA THOMAS JEFFERSON (S 222)
SENSOR ALIGNMENT & ORTHOGONAL COORDINATE SURVEY
JULY-AUGUST 2016

FINAL REPORT

September 1, 2016 - Rev “1”

Prepared By:

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CONTENTS

ELECTRONIC FILES TRANSMITTED WITH THIS REPORT

Raw Data-World.txt
Report Tables
- Kongsberg system.xlsx
- EM710TX system.xlxs
- IMU System.xlsx
- ORU System.xlsx

PROJECT OVERVIEW

Purpose

The purpose of this commentary is to summarize the procedures and analytical methods employed to perform the 3-D coordinate total station inspection that produced the data in this report for those unfamiliar with the equipment and process.

Dimensional data resulting from the inspection is included with the report.

General Comments

This report summarizes coordinate measurement data taken on the vessel NOAA Thomas Jefferson July 27 and 28, 2016 and August 22 thru 26, 2016. The vessel was located in a graving dock at US Coast Guard Yard, 2104 Hawkins Point Road, Baltimore, MD.

Coordinate measurements were taken to characterize the vessel and create the required reference coordinate system for reporting azimuth, pitch, roll and coordinate data.

Coordinate measurements were then taken to define elements and features according to the SOW MOA2-11(15) Dated December 8, 2015 and as requested by NOAA representatives in support of the EM710 Multi-Beam Sounding system transducer installation.

Locations of existing draft marks were measured and recorded.

3-D Coordinate Measurement Equipment

A Sokkia NET 1200 enhanced electronic total station operated through a notebook computer running New River Kinematics Spatial Analyzer™ measurement and analysis software was utilized. This system measures 3-D spherical coordinates by recording an azimuth and zenith angle simultaneously with the near infrared distance coaxial with the telescope line of sight for each observation. Spatial Analyzer measurement and analysis software converts the spherical coordinate data to a Cartesian coordinate system that can be defined by the user. Measurements are made to either adhesive or kinematic targets that have a retro-reflective target face.

Temporary "benchmarks" or reference points were placed throughout the dry-dock area and on the vessel as required to allow for re-locating the instrument to a new position or "Station" and tie all of the data to the common coordinate system for comparison.

The measuring system used for this final inspection report is one of several owned by The IMTEC Group, Ltd. The NET 1200 total station, S/N 110554 was calibrated, traceable to N.I.S.T. and in accordance with A.N.S.I. Z-540-1, at the Sokkia USA Factory Service Center November 17, 2015.

Reference Coordinate Systems

The following parameters were used to define the reference coordinate system for reporting the survey data per Kongsberg and NOAA representatives.

Kongsberg requested vessel coordinate system:

Origin: Top Dead Center (TDC) of the Inertial Measurement Unit (IMU):
X=0.000, Y=0.000, Z=0.000

Pitch and Azimuth:

Ten (10) Pairs of points were surveyed from approximately Frame 90 through Frame 10 on the Keel plate and then bisected to obtain a center point. These points were then projected onto the keel plane and used to construct a best fit line. A Best fit line faired through these points determined the ship system azimuth (X-Axis) and Pitch.

Roll: Six points were measured port/stbd, and fwd/aft and ~center port/stbd to determine the plane of the aft deck. This plane was used to establish roll.

Thus the vessel coordinate system is depicted as shown:

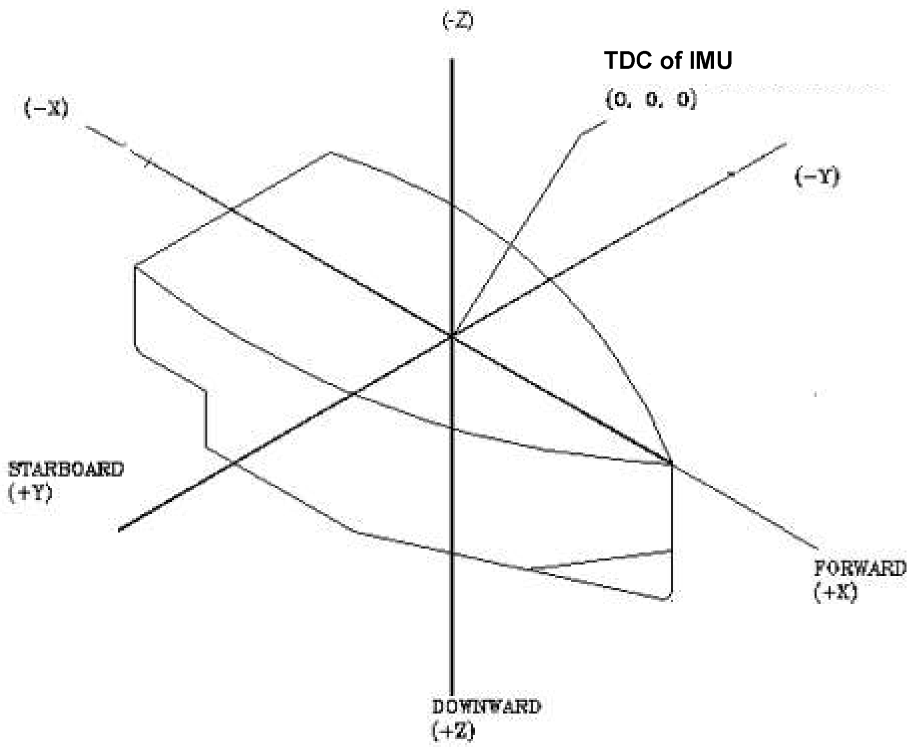

Figure 1 – Vessel Coordinate System

The first coordinate system requested by NOAA is defined as follows:

Origin: Center of TX Transducer Frame: X=0.000, Y=0.000, Z=0.000
Pitch: Plane of TX Transducer Frame.
Roll: Plane of TX Transducer Frame.
X Axis: Azimuth of TX Transducer Frame X axis Positive Forward.
Z Axis: Normal to Plane of TX Transducer Frame axis Positive towards keel

The TX Frame therefore completely defines a vessel coordinate system.

The second coordinate system requested by NOAA is defined as follows:

Origin:	TDC target on IMU: X=0.000, Y=0.000, Z=0.000
Pitch:	Plane of IMU
Roll:	Plane of IMU
X Axis:	Azimuth of IMU X axis Positive Forward
Z Axis:	Normal to Plane of IMU axis Positive Towards keel

IMU therefore completely defines a vessel coordinate system.

The third coordinate system requested by NOAA is defined as follows:

Origin:	TDC target on ORU: X=0.000, Y=0.000, Z=0.000
Pitch:	Plane of ORU
Roll:	Plane of ORU
X Axis:	Azimuth of ORU X axis Positive Forward
Z Axis:	Normal to Plane of ORU axis positive Towards keel

ORU therefore completely defines a vessel coordinate system.

NOAA Representative requested that all survey data be presented in these coordinate systems including the draft marks.

Figure 2- Optical Reference Unit (ORU)

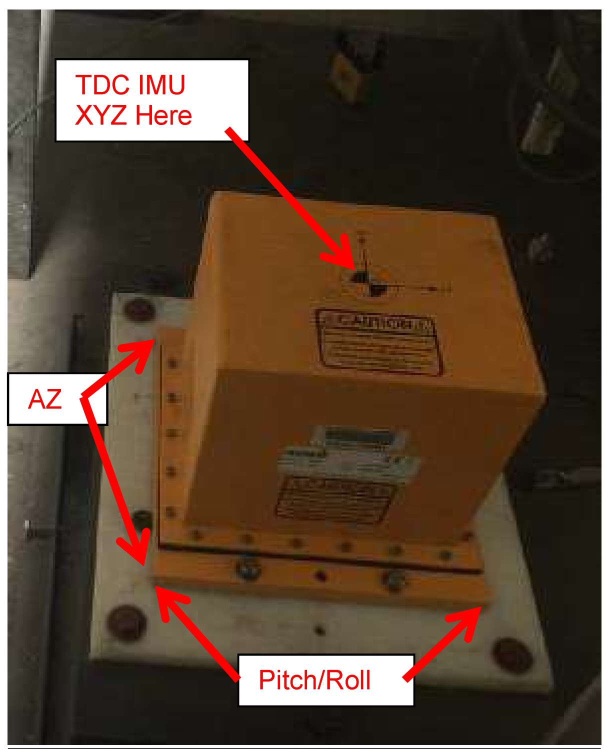

Figure 3- Inertial Measurement Unit (IMU)

Measurement Procedure

Adhesive targets with retro reflective target face were used throughout the survey as temporary benchmarks for relocating the instrument to new stations. Kinematic (a target with a known offset) retro reflective targets such as the RT-50M swivel targets were frequently used as a temporary benchmark. The Sokkia NET 1200 total station operated through a notebook computer running Spatial Analyzer™ industrial measurement software was used to measure the targets and record observations.

Gondola Installation

At the request of shipyard and NOAA personnel, IMTEC assisted with proper positioning of the gondola to within the azimuth, pitch and roll tolerances required by Kongsberg prior to welding.

EM 710TX, EM 710RX and EM2040 Transducer Frames

After the transducer frames were installed, data points were surveyed at each of the bolt locations to determine overall flatness. Shim values were provided to Kongsberg to meet the flatness requirement. After shims were added and bolts final torqued, the frames were again surveyed to document final flatness. Final location (X, Y, Z), pitch, roll and azimuth of the Kongsberg transducers frames with respect to the vessel coordinate system were determined.

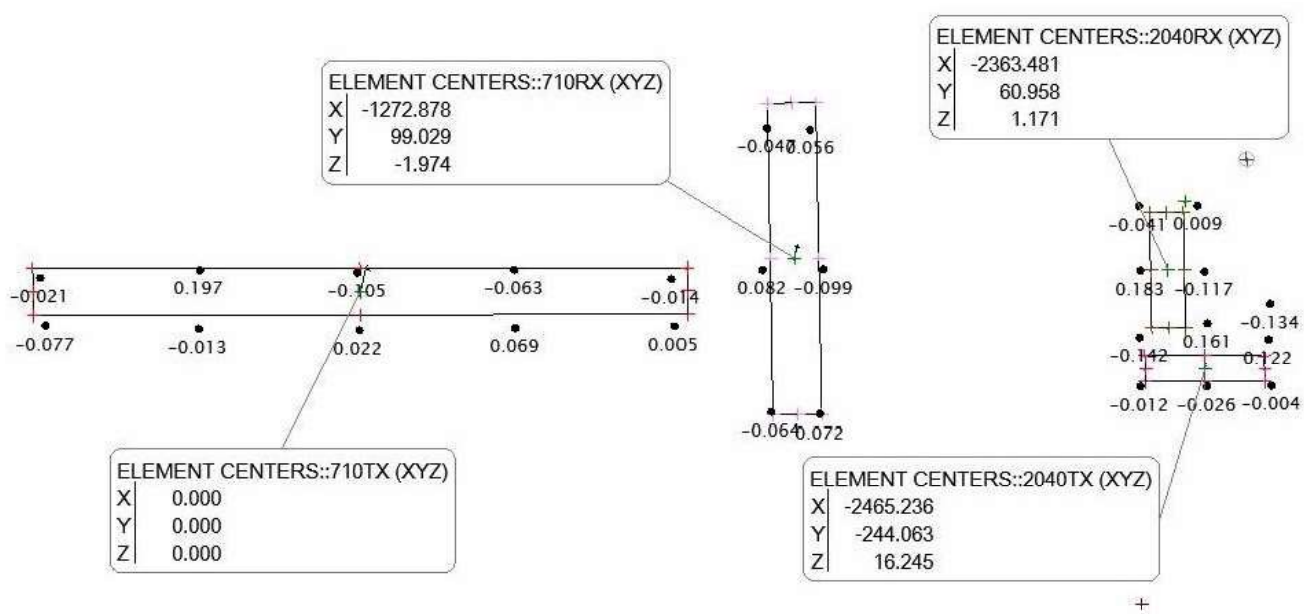

Figure 4-Flatness EM710 TX/RX and EM2040 TX/RX as Installed (mm)

Vessel Benchmarks and Navigation Elements

Existing benchmarks and elements were surveyed as part of this effort and values for each are reported in the requested vessel orthogonal coordinate system. Additional benchmarks were added at the top of mast, at the starboard side of aft deck and at the top of the pilot house.

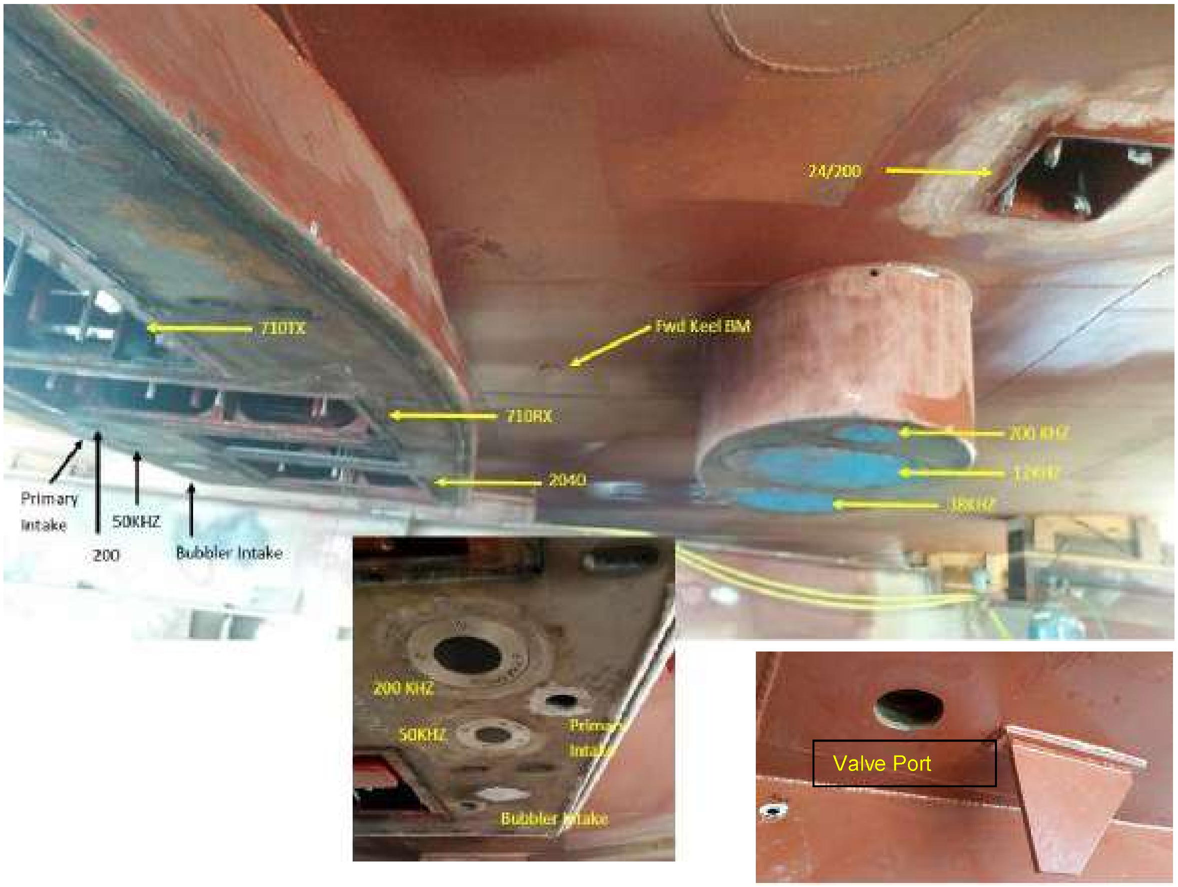

Figure 5-Elements at Bottom of Hull

Figure 6-Elements at Starboard side of Gondola

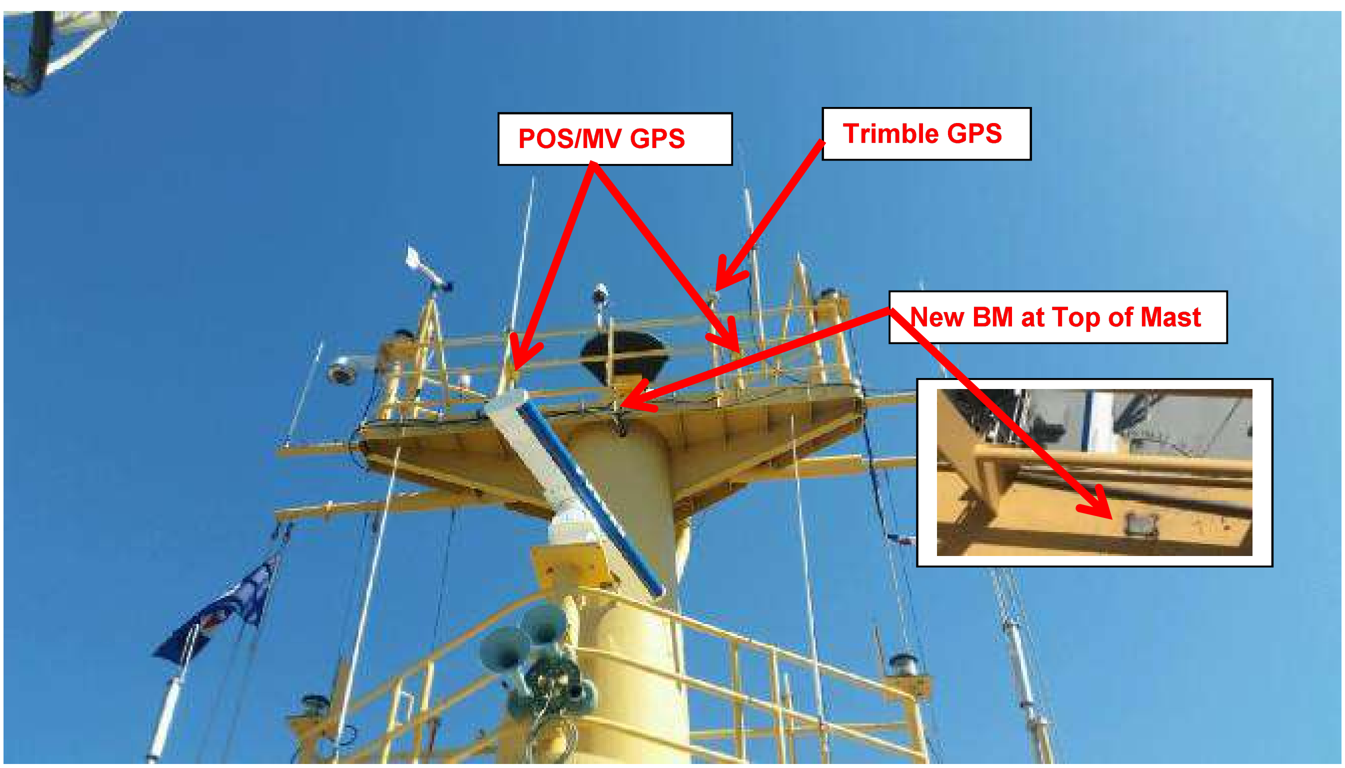

Figure 7- Mast Elements

Figure 8-GPS Antenna Elevations at bottom of Mount

Figure 9 – Scientific Store Room

BM#1


BM#2


BM#3


BM#4


BM#5


BM#6


BM#7


BM#12


BM#13


BM#14


New Aft BM


New BM Top Pilot House

Figure 10 – Bench Marks

Measurement Precision and Uncertainty

Uncertainties are reported to be:

Point to Point, any element or target within the vessel survey to another element or feature in the survey

X, Y, & Z $\leq$ 1.5 mm

Region to Region, i.e., GPS antenna to EM710 RX/TX features:

X $\leq$ 2.0 mm
Y $\leq$ 2.0 mm
Z $\leq$ 2.0 mm

The angular measurement precision of the NET1200 is < 1 arc second in azimuth and zenith. There can be some error introduced by targeting. Random and systematic errors can be introduced by the working environment.

The expected angular precision of the survey is analyzed to be:

Azimuth, Pitch, Roll: ≤ 00° 00' 30"

PROJECT DATA

The required data is summarized in tabular form on the following pages. The units of measure for reporting are indicated on each table.

Table 1 reports the X, Y and Z, values for specified elements in units of meters and in the vessel coordinate system (Kongsberg System)

Table 2 reports the X, Y and Z, values for specified bench marks in units of meters and in the vessel coordinate system (Kongsberg system).

Table 3 reports the Azimuth, Pitch and Roll of specified elements in Kongsberg system.

Table 4 reports the summarized data for the draft mark survey and is presented with Feet as the unit of measure to correlate with the specific draft mark number. Draft mark elevations are reported above the best-fit keel as surveyed. The gondola projection is not reflected by any set of draft marks and projects 1.4 feet below the keel.

Appendix 1 is a copy of tables with the data presented with respect to the 1st coordinate system requested by NOAA EM710Tx Transducer Center as Origin and plane defining Pitch & Roll with azimuth clocked to X axis of transducer.

Appendix 2 is a copy of tables with the data presented with respect to the 2nd coordinate system requested by NOAA; IMU Center as Origin and plane IMU defining Pitch & Roll with azimuth clocked to X axis of IMU.

Appendix 3 is a copy of tables with the data presented with respect to the 3rd coordinate system requested by NOAA; ORU Center as Origin and ORU plane defining Pitch & Roll with azimuth clocked to X axis of ORU.

[3]TABLE 1-ELEMENT COORDINATES SHIP SYSTEM (m)			
ELEMENT	**X**	**Y**	**Z**
IMU (XYZ)	0.000	0.000	0.000
ORU (ORIGIN)	-0.843	-0.012	-0.132
710TX (XYZ)	-0.488	2.333	5.010
710RX (XYZ)	-1.760	2.434	5.008
2040RX (XYZ)	-2.851	2.397	5.012
2040TX (XYZ)	-2.953	2.092	5.027
[1]BUBBLER ORIFICE Z	-2.989	2.926	3.917
24/200 (XYZ)	-1.264	0.305	4.439
200KHZ_1 (XYZ)	-1.911	0.573	4.887
12KHZ_1 (XYZ)	-2.431	0.570	4.887
38KHZ (XYZ)	-3.084	0.567	4.890
3.5KHZ (XYZ)	-1.873	6.032	4.398
SEC INTAKE (XYZ)	-3.106	7.784	4.187
SRD500 (XYZ)	-3.066	5.183	4.594
VALVE PORT (XYZ)	-2.950	3.250	4.564
BUBBLER INTAKE (XYZ)	-3.090	2.733	5.010
50KHZ (XYZ)	-2.611	2.881	5.012
PRIMARY INTAKE (XYZ)	-2.487	3.013	5.010
200KHZ_2 (XYZ)	-2.344	2.882	5.012
12KHZ_2 (XYZ)	-1.272	4.555	4.438
[2]TRIMBLE GPS	-9.040	1.575	-22.214
[2]POS MV PORT	-9.924	1.373	-22.344
[2]POS MV STBD	-9.913	3.583	-22.335

(1) Bubbler Orfice Z (X and Y approx)
(2) Z at Base, see Figure 8
(3) Kongsberg System Ships Orthogonal system on TDC IMU

TABLE 2- BENCH MARKS SHIP SYSTEM (m)			
BENCH MARK	X	Y	Z
SCI STORE FWD #1	1.027	-0.567	0.287
SCI STORE INTR #2	-1.132	-0.577	0.291
SCI STORE AFT #3	-3.294	-0.589	0.289
FWD KEEL #4	-2.787	1.515	4.555
AFT KEEL #5	-16.152	1.51	4.557
MAIN PASS #6	-6.435	3.337	-2.517
DC PASS #7	-16.141	3.287	-2.51
BOW FWD #12	21.026	2.535	-5.183
BOW MID #13	17.187	2.516	-5.175
BOW AFT#14	14.643	2.512	-5.192
PILOT HOUSE (NEW)	-7.568	5.304	-12.92
TOP MAST (NEW)	-9.151	2.942	-20.999
STBD AFT END (New)	-39.506	7.544	-3.079

TABLE 3 - HEADING, PITCH. ROLL OF ELEMENTS (decimal dgrees)						
ELEMENT	HEADING		PITCH		ROLL	
	VALUE	DIRECTION	VALUE	DIRECTION	VALUE	DIRECTION
SHIP SYSTEM	0.00000	-	0.00000	-	0.00000	-
IMU	0.64167	STBD	0.07198	BOW DOWN	0.24375	STBD DOWN
ORU	0.04400	PORT	0.08500	BOW DOWN	0.07779	STBD DOWN
EM710 TX	0.05539	PORT	0.01315	BOW UP	0.00927	STBD UP
EM710RX	0.21797	STBD	0.09935	BOW UP	0.06457	STBD DOWN
EM2040TX	0.1466	STBD	0.19035	BOW UP	0.08625	STBD UP
EM2040RX	0.13963	STBD	0.20005	BOW UP	0.17817	STBD UP

TABLE 4 - DRAFT MARKS (elev above keel, feet)							
PORT				STARBOARD			
DRAFT MARK	ELEVATION AS SURVEYED			DRAFT MARK	ELEVATION AS SURVEYED		
	FWD	MID	AFT		FWD	MID	AFT
12	-	-	-	12	-	11.9	-
13	12.9	-	-	13	12.9	-	-
14	13.9	14.0	-	14	13.9	13.9	-
15	15.0	15.0	15.1	15	15.0	14.9	15.1
16	16.0	16.0	16.1	16	16.0	15.9	16.0
17	16.9	17.0	17.1	17	16.9	16.9	17.1

Certificate of Calibration

Item No. / Model: NET 1200

Manufacturer: SOKKIA

Serial No.: 110554 Certificate Number: 60997

This certifies that the above instrument has been inspected and calibrated by the Sokkia Corporation Service Department. This inspection was performed using the procedures set forth in the NET SERIES INSTRUMENT CALIBRATION AND CERTIFICATION MANUAL (August 18, 2005 Rev. 8). At the time of completion of this service, Sokkia Corporation certifies that the above stated instrument meets or exceeds all factory specifications and tolerances for instrument parameters and performance of this instrument model. The certification is effective for a 12 month period from the calibration date shown below.

All distance measurement parameters were tested and adjusted using factory calibration jigs and with the 10 Meter Calibration Rail whose accuracy is traceable to the National Institute of Standards and Technology (N.I.S.T) via Multual Recognition Agreement. All angle measurement parameters were tested with a NIST traceable optical collimation system, using accepted collimation and adjustment procedures.

The quality system addresses and conforms to ANSI/NCSL Z540-1-1994 and ISO/IEC 17025-1999 (and, as a result ISO 9001-1994 or ISO 9002-1994)

This certificate shall not be reproduced except in full, without the written approval of Sokkia Corporation

Customer Name: IMTEC GROUP, Ltd

Customer Address: 19004 E. RINGO CIR.

Customer City/State/Zip: INDEPENDENCE, MO 64057

See individual sets of data for temperature and pressure

Date Calibrated: 11/17/2015 Date Recalibration Due: 11/17/2016

Signed: [signature] Date: 11/17/2015

Yes	No	
	X	Is this a new instrument?

Answer the following questions only if the above answer is "No".

Yes	No	
	X	Is this the first NIST calibration we have performed on this instrument?
X		Were the calibration seals intact when the instrument was received?
	X	Were the initial collimation inspection results within tolerance?
	X	Were the initial EDM inspection results within tolerance?
	X	Was the instrument damaged/defective and unable to have an initial inspection?
	X	Corrective action recommended?

* See page 2 for a list of primary standards

Page 1 of 2

Appendix 1 – NOAA Requested System wrt 710TX

(3) A1 TABLE 1-ELEMENT COORDINATES 710TX SYSTEM (m)			
ELEMENT	**X**	**Y**	**Z**
IMU (XYZ)	0.491	-2.332	-5.010
ORU (ORIGIN)	-0.351	-2.345	-5.143
710TX (XYZ)	0.000	0.000	0.000
710RX (XYZ)	-1.273	0.099	-0.002
2040RX (XYZ)	-2.363	0.061	0.001
2040TX (XYZ)	-2.465	-0.244	0.016
(1)BUBBLER ORIFICE Z	-2.501	0.590	-1.094
24/200 (XYZ)	-0.774	-2.029	-0.571
200KHZ_1 (XYZ)	-1.421	-1.762	-0.124
12KHZ_1 (XYZ)	-1.942	-1.765	-0.123
38KHZ (XYZ)	-2.594	-1.769	-0.121
3.5KHZ (XYZ)	-1.389	3.698	-0.612
SEC INTAKE (XYZ)	-2.623	5.448	-0.823
SRD500 (XYZ)	-2.581	2.847	-0.417
VALVE PORT (XYZ)	-2.463	0.914	-0.447
BUBBLER INTAKE (XYZ)	-2.603	0.397	-0.001
50KHZ (XYZ)	-2.124	0.545	0.002
PRIMARY INTAKE (XYZ)	-2.000	0.678	0.000
200KHZ_2 (XYZ)	-1.857	0.546	0.002
12KHZ_2 (XYZ)	-0.786	2.221	-0.572
(2)TRIMBLE GPS	-8.545	-0.762	-27.226
(2)POS MV PORT	-9.429	-0.965	-27.357
(2)POS MV STBD	-9.420	1.245	-27.347

(1) Bubbler Orfice Z (X and Y approx)
(2) Z at Base, see Figure 8
(3) NOAA Requested System 1 Orthogonal system on 710TX

A1 TABLE 2- BENCH MARKS 710TX SYSTEM (m)			
BENCH MARK	X	Y	Z
SCI STORE FWD #1	1.519	-2.898	-4.723
SCI STORE INTR #2	-0.64	-2.911	-4.72
SCI STORE AFT #3	-2.803	-2.924	-4.722
FWD KEEL #4	-2.299	-0.82	-0.456
AFT KEEL #5	-15.663	-0.838	-0.457
MAIN PASS #6	-5.946	1	-7.528
DC PASS #7	-15.652	0.94	-7.523
BOW FWD #12	21.516	0.224	-10.189
BOW MID #13	17.677	0.201	-10.181
BOW AFT#14	15.133	0.195	-10.198
PILOT HOUSE (NEW)	-7.079	2.967	-17.931
TOP MAST (NEW)	-8.658	0.604	-26.011
STBD AFT END (New)	-39.022	5.174	-8.097

A1 -TABLE 3 - HEADING, PITCH. ROLL OF ELEMENTS 710 TX SYSTEM (decimal dgrees)						
ELEMENT	HEADING		PITCH		ROLL	
	VALUE	DIRECTION	VALUE	DIRECTION	VALUE	DIRECTION
IMU	0.69705	STBD	0.08490	BOW DOWN	0.25310	STBD DOWN
ORU	0.01138	STBD	0.09813	BOW DOWN	0.08710	STBD DOWN
EM710 TX	0.00000	-	0.00000	-	0.00000	-
EM710RX	0.27337	STBD	0.08627	BOW UP	0.07377	STBD DOWN
EM2040TX	0.20202	STBD	0.17713	BOW UP	0.07714	STBD UP
EM2040RX	0.19498	STBD	0.18675	BOW UP	0.16907	STBD UP

Appendix 2 – NOAA Requested System wrt IMU

(3) A2- TABLE 1-ELEMENT COORDINATES IMU SYSTEM (m)			
ELEMENT	**X**	**Y**	**Z**
(4)IMU (XYZ)	0	0	0
ORU (ORIGIN)	-0.843	-0.003	-0.131
710TX (XYZ)	-0.455	2.36	5.001
710RX (XYZ)	-1.727	2.474	5
2040RX (XYZ)	-2.818	2.45	5.005
2040TX (XYZ)	-2.923	2.146	5.022
(1)BUBBLER ORIFICE Z	-2.951	2.975	3.908
24/200 (XYZ)	-1.255	0.338	4.44
200KHZ_1 (XYZ)	-1.898	0.615	4.887
12KHZ_1 (XYZ)	-2.418	0.618	4.888
38KHZ (XYZ)	-3.071	0.623	4.892
3.5KHZ (XYZ)	-1.8	6.071	4.375
SEC INTAKE (XYZ)	-3.013	7.836	4.157
SRD500 (XYZ)	-3.002	5.237	4.575
VALVE PORT (XYZ)	-2.908	3.302	4.554
BUBBLER INTAKE (XYZ)	-3.053	2.789	5.002
50KHZ (XYZ)	-2.572	2.931	5.003
PRIMARY INTAKE (XYZ)	-2.447	3.062	5
200KHZ_2 (XYZ)	-2.305	2.929	5.003
12KHZ_2 (XYZ)	-1.215	4.588	4.42
(2)TRIMBLE GPS	-9.051	1.582	-22.209
(2)POS MV PORT	-9.937	1.389	-22.338
(2)POS MV STBD	-9.901	3.599	-22.337

(1) Bubbler Orfice Z (X and Y approx)
(2) Z at Base, see Figure 8
(3) NOAA Requested System 2 Orthogonal system on IMU
(4)TDC IMU is 4.6 meters above Keel

A2 TABLE 2- BENCH MARKS IMU SYSTEM (m)			
BENCH MARK	X	Y	Z
SCI STORE FWD #1	1.021	-0.577	0.289
SCI STORE INTR #2	-1.138	-0.563	0.294
SCI STORE AFT #3	-3.300	-0.550	0.296
FWD KEEL #4	-2.764	1.566	4.552
AFT KEEL #5	-16.128	1.710	4.571
MAIN PASS #6	-6.400	3.399	-2.523
DC PASS #7	-16.106	3.457	-2.503
BOW FWD #12	21.046	2.277	-5.221
BOW MID #13	17.207	2.301	-5.207
BOW AFT#14	14.664	2.326	-5.221
PILOT HOUSE (NEW)	-7.525	5.334	-12.932
TOP MAST (NEW)	-9.145	2.955	-21.000
STBD AFT END (New)	-39.423	7.973	-3.061

A2 -TABLE 3 - HEADING, PITCH. ROLL OF ELEMENTS (decimal dgrees IMU System)						
ELEMENT	HEADING		PITCH		ROLL	
	VALUE	DIRECTION	VALUE	DIRECTION	VALUE	DIRECTION
IMU	0.00000	-	0.00000	-	0.00000	-
ORU	0.68556	PORT	0.01122	BOW DOWN	0.16615	STBD UP
EM710 TX	0.69738	PORT	0.08796	BOW UP	0.25206	STBD UP
EM710RX	0.42371	PORT	0.17333	BOW UP	0.17725	STBD UP
EM2040TX	0.49611	PORT	0.26602	BOW UP	0.32704	STBD UP
EM2040RX	0.50177	PORT	0.27675	BOW UP	0.41885	STBD UP

Appendix 3 – NOAA Requested Coordinates wrt ORU

(3) A3 TABLE 1-ELEMENT COORDINATES ORU SYSTEM (m)			
ELEMENT	**X**	**Y**	**Z**
(4)IMU (XYZ)	0.843	0.013	0.131
ORU (ORIGIN)	0.000	0.000	0.000
710TX (XYZ)	0.361	2.353	5.139
710RX (XYZ)	-0.912	2.452	5.139
2040RX (XYZ)	-2.003	2.414	5.144
2040TX (XYZ)	-2.105	2.109	5.160
(1)BUBBLER ORIFICE Z	-2.142	2.941	4.048
24/200 (XYZ)	-0.415	0.322	4.572
200KHZ_1 (XYZ)	-1.061	0.591	5.020
12KHZ_1 (XYZ)	-1.582	0.587	5.021
38KHZ (XYZ)	-2.234	0.584	5.025
3.5KHZ (XYZ)	-1.029	6.049	4.524
SEC INTAKE (XYZ)	-2.263	7.800	4.312
SRD500 (XYZ)	-2.221	5.200	4.722
VALVE PORT (XYZ)	-2.103	3.266	4.695
BUBBLER INTAKE (XYZ)	-2.242	2.750	5.142
50KHZ (XYZ)	-1.763	2.898	5.143
PRIMARY INTAKE (XYZ)	-1.639	3.031	5.141
200KHZ_2 (XYZ)	-1.496	2.899	5.143
12KHZ_2 (XYZ)	-0.426	4.573	4.565
(2)TRIMBLE GPS	-8.231	1.550	-22.071
(2)POS MV PORT	-9.115	1.348	-22.201
(2)POS MV STBD	-9.106	3.558	-22.194

(1) Bubbler Orfice Z (X and Y approx)
(2) Z at Base, see Figure 8
(3) NOAA Requested System 3 Orthogonal system on ORU
(4)TDC ORU is 4.7 meters above Keel

A3 TABLE 2- BENCH MARKS ORU SYSTEM (m)			
BENCH MARK	X	Y	Z
SCI STORE FWD #1	1.871	-0.553	0.418
SCI STORE INTR #2	-0.288	-0.565	0.424
SCI STORE AFT #3	-2.451	-0.578	0.426
FWD KEEL #4	-1.939	1.532	4.688
AFT KEEL #5	-15.304	1.517	4.710
MAIN PASS #6	-5.598	3.342	-2.381
DC PASS #7	-15.304	3.284	-2.359
BOW FWD #12	21.859	2.556	-5.087
BOW MID #13	18.020	2.535	-5.072
BOW AFT#14	15.476	2.529	-5.086
PILOT HOUSE (NEW)	-6.749	5.294	-12.784
TOP MAST (NEW)	-8.342	2.919	-20.858
STBD AFT END (New)	-38.674	7.522	-2.900

A3 -TABLE 3 - HEADING, PITCH. ROLL OF ELEMENTS (decimal dgrees ORU System)						
ELEMENT	HEADING		PITCH		ROLL	
	VALUE	DIRECTION	VALUE	DIRECTION	VALUE	DIRECTION
IMU	0.68529	STBD	0.01321	BOW UP	0.16601	STBD DOWN
ORU	0.00000	-	0.00000	-	0.00000	-
EM710 TX	0.01276	PORT	0.09815	BOW UP	0.08708	STBD UP
EM710RX	0.26191	STBD	0.18441	BOW UP	0.01330	STBD UP
EM2040TX	0.18694	STBD	0.27532	BOW UP	0.16419	STBD UP
EM2040RX	0.18391	STBD	0.28496	BOW UP	0.25613	STBD UP
24/200 kHz	-	-	0.47762	BOW UP	0.02678	STBD DOWN
12kHz-2	-	-	0.36558	BOW UP	0.23158	STBD UP
12kHz-1	-	-	0.23913	BOW UP	0.09000	STBD UP
200kHz-1	-	-	0.13427	BOW UP	0.46860	STBD UP
200kHz-2	-	-	0.08863	BOW UP	0.32335	STBD UP
38kHz	-	-	0.32417	BOW UP	0.01594	STBD DOWN
50kHz	-	-	0.34673	BOW UP	0.43530	STBD UP
SRD500	-	-	0.54483	BOW UP	0.71415	STBD DOWN
3.5 kHz	-	-	0.17175	BOW UP	0.04851	STBD DOWN
ADCP(1)	-	-	-	-	-	-

(1) ADCP not installed at time of survey

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Vessel Name: 2903_Reson7125_SV2_400kHz_2017.hvf
Vessel created: January 23, 2018


Depth Sensor:

    Sensor Class:    Swath
    Time Stamp:  2017-121 00:00

    Comments: Initial measurements
    Time Correction(s) 0.000

    Transduer #1:
    -------------
    Pitch Offset:   0.000
    Roll Offset:    0.000
    Azimuth Offset: 0.000

    DeltaX: 0.000
    DeltaY: 0.000
    DeltaZ: 0.000

    Manufacturer:    Reson
    Model:       sb7125d
    Serial Number:
```

```
Navigation Sensor:

    Time Stamp:  2017-121 00:00

    Comments: (null)
    Time Correction(s) 0.000
    DeltaX: 0.000
    DeltaY: 0.000
    DeltaZ: 0.000

    Manufacturer:    (null)
    Model:       (null)
    Serial Number:   (null)
```

```
Gyro Sensor:

    Time Stamp:  2017-121 00:00

    Comments:
    Time Correction(s) 0.000
```

```
Heave Sensor:

    Time Stamp:  2017-121 00:00

    Comments: (null)
    Apply Yes
    Time Correction(s) 0.000
    DeltaX: 0.000
    DeltaY: 0.000
    DeltaZ: 0.000
    Offset: 0.000

    Manufacturer:    (null)
    Model:       (null)
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    Serial Number:   (null)

Pitch Sensor:

    Time Stamp:  2017-121 00:00

    Comments: (null)
    Apply Yes
    Time Correction(s) 0.000
    Pitch offset: 0.000

    Manufacturer:    (null)
    Model:       (null)
    Serial Number:   (null)

Roll Sensor:

    Time Stamp:  2017-121 00:00

    Comments: (null)
    Apply Yes
    Time Correction(s) 0.000
    Roll offset: 0.000

    Manufacturer:    (null)
    Model:       (null)
    Serial Number:   (null)

Draft Sensor:

    Time Stamp:  2017-121 00:00

    Apply Yes
    Comments: (null)
    Time Correction(s) 0.000

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    Entry 3) Draft: 0.020   Speed: 1.944
    Entry 4) Draft: 0.030   Speed: 2.916
    Entry 5) Draft: 0.040   Speed: 3.888
    Entry 6) Draft: 0.050   Speed: 4.860
    Entry 7) Draft: 0.060   Speed: 5.832
    Entry 8) Draft: 0.060   Speed: 6.803
    Entry 9) Draft: 0.060   Speed: 7.775
    Entry 10) Draft: 0.050  Speed: 8.747
    Entry 11) Draft: 0.040  Speed: 9.719
    Entry 12) Draft: 0.020  Speed: 10.691
    Entry 13) Draft: -0.010 Speed: 11.663
    Entry 14) Draft: -0.050 Speed: 12.635
    Entry 15) Draft: -0.090 Speed: 13.607

TPU

    Time Stamp:  2017-121 00:00

    Comments:
    Offsets

    Motion sensing unit to the transducer 1
        X Head 1 0.002
```

```
        Y Head 1 0.271
        Z Head 1 0.526
    Motion sensing unit to the transducer 2
        X Head 2 0.000
        Y Head 2 0.000
        Z Head 2 0.000
    Navigation antenna to the transducer 1
        X Head 1 0.721
        Y Head 1 1.013
        Z Head 1 4.207
    Navigation antenna to the transducer 2
        X Head 2 0.000
        Y Head 2 0.000
        Z Head 2 0.000

    Roll offset of transducer number 1 0.000
    Roll offset of transducer number 2 0.000

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    Measurement errors: 0.020
    Motion sensing unit alignment errors
    Gyro:0.080  Pitch:0.110 Roll:0.110
    Gyro measurement error: 0.015
    Roll measurement error: 0.005
    Pitch measurement error: 0.005
    Navigation measurement error: 0.500
    Transducer timing error: 0.003
    Navigation timing error: 0.003
    Gyro timing error: 0.003
    Heave timing error: 0.003
    PitchTimingStdDev: 0.003
    Roll timing error: 0.003
    Sound Velocity speed measurement error: 0.000
    Surface sound speed measurement error: 0.000
    Tide measurement error: 0.000
    Tide zoning error: 0.000
    Speed over ground measurement error: 0.100
    Dynamic loading measurement error: 0.030
    Static draft measurement error: 0.030
    Delta draft measurement error: 0.020
    StDev Comment: (null)
```

```
Svp Sensor:

    Time Stamp:  2017121:0000

    Comments: (null)
    Time Correction(s) 0.000

    Svp #1:
    -------------
    Pitch Offset:   0.000
    Roll Offset:    0.000
    Azimuth Offset: 0.000

    DeltaX: 0.002
    DeltaY: 0.271
    DeltaZ: 0.526

    SVP #2:
    -------------
    Pitch Offset:   0.000
    Roll Offset:    0.000
    Azimuth Offset: 0.000
```

DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

WaterLine:

Time Stamp: 2017-121 00:00

Comments: (null)
Apply Yes
WaterLine -0.128

Vessel Name: 2903_SSS_100_2017.hvf
Vessel created: January 23, 2018

Navigation Sensor:

Time Stamp: 2017-231 00:00

Comments: (null)
Time Correction(s) 0.000
DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Manufacturer: Applanix
Model: POS M/V V4
Serial Number: (null)

Gyro Sensor:

Time Stamp: 2017-231 00:00

Comments: (null)
Time Correction(s) 0.000

Tow Point:

Time Stamp: 2017-001 00:00

Comments:
Time Correction(s) 0.000
DeltaX: 0.564
DeltaY: 0.654
DeltaZ: 0.310

Manufacturer:
Model:
Serial Number:

```
Vessel Name: 2903_SSS_200_2017.hvf
Vessel created: January 23, 2018


Navigation Sensor:

    Time Stamp:  2017-231 00:00

    Comments: (null)
    Time Correction(s) 0.000
    DeltaX: 0.000
    DeltaY: 0.000
    DeltaZ: 0.000

    Manufacturer:    Applanix
    Model:       POS M/V V4
    Serial Number:   (null)
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```
Gyro Sensor:

    Time Stamp:  2017-231 00:00

    Comments: (null)
    Time Correction(s) 0.000
```

```
Tow Point:

    Time Stamp:  2017-001 00:00

    Comments:
    Time Correction(s) 0.000
    DeltaX: 0.564
    DeltaY: 0.654
    DeltaZ: 0.310

    Manufacturer:
    Model:
    Serial Number:
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      <WaterLine value="0.510000"/>
      <ApplyFlag value="Yes"/>
      <StdDev Waterline="0.000000"/>
    </TimeStamp>
    <TimeStamp value="2017-231 00:00:00">
      <Comment value=""/>
      <Latency value="0.000000"/>
      <WaterLine value="0.469130"/>
      <ApplyFlag value="Yes"/>
      <StdDev Waterline="0.000000"/>
    </TimeStamp>
    <TimeStamp value="2017-257 00:00:00">
      <Comment value=""/>
      <Latency value="0.000000"/>
      <WaterLine value="0.316000"/>
      <ApplyFlag value="Yes"/>
      <StdDev Waterline="0.000000"/>
    </TimeStamp>
    <TimeStamp value="2017-298 00:00:00">
      <Comment value=""/>
      <Latency value="0.000000"/>
      <WaterLine value="0.369000"/>
      <ApplyFlag value="Yes"/>
      <StdDev Waterline="0.000000"/>
    </TimeStamp>
  </WaterlineHeight>
  <SVPSensor>
    <TimeStamp value="2016-278 00:00:00">
      <Comment value=""/>
      <Latency value="0.000000"/>
      <DualHead value="Yes"/>
      <Offsets X="2.146000" Y="-2.923000" Z="5.022000" X2="2.450000" Y2="-2.818000"
      Z2="5.005000"/>
      <MountAngle Pitch="-0.266000" Roll="0.327000" Azimuth="179.504000" Pitch2="-0.277000"
      Roll2="0.419000" Azimuth2="179.498000"/>
    </TimeStamp>
  </SVPSensor>
  <DepthSensor>
    <TimeStamp value="2016-278 00:00:00">
      <Latency value="0.000000"/>
      <SensorClass value="Swath"/>
      <TransducerEntries>
        <Transducer Number="1" StartBeam="1" Model="em2040_300N">
          <Offsets X="0.000000" Y="0.000000" Z="0.000000" Latency="0.000000"/>
          <MountAngle Pitch="0.010000" Roll="-0.040000" Azimuth="0.017000"/>
        </Transducer>
        <Transducer Number="2" StartBeam="1002" Model="em2040_300N">
          <Offsets X="0.000000" Y="0.000000" Z="0.000000" Latency="0.000000"/>
          <MountAngle Pitch="0.000000" Roll="0.000000" Azimuth="0.000000"/>
        </Transducer>
      </TransducerEntries>
    </TimeStamp>
    <TimeStamp value="2017-001 00:00:00">
      <Latency value="0.000000"/>
      <SensorClass value="Swath"/>
      <TransducerEntries>
        <Transducer Number="1" StartBeam="1" Model="em2040_300N">
          <Manufacturer value="Kongsberg EM2040 300kHz 0.5x1_Normal Mode"/>
```

```
          <Offsets X="0.000000" Y="0.000000" Z="0.000000" Latency="0.000000"/>
          <MountAngle Pitch="0.000000" Roll="0.000000" Azimuth="0.000000"/>
        </Transducer>
        <Transducer Number="2" StartBeam="2" Model="Unknown">
          <Offsets X="0.000000" Y="0.000000" Z="0.000000" Latency="0.000000"/>
          <MountAngle Pitch="0.000000" Roll="0.000000" Azimuth="0.000000"/>
        </Transducer>
      </TransducerEntries>
    </TimeStamp>
  </DepthSensor>
  <TPEConfiguration>
    <TimeStamp value="2015-001 00:00:00">
      <Comment value=""/>
      <Latency value="0.000000"/>
      <Offsets>
        <MRUtoTransducer X="2.146000" Y="-2.923000" Z="5.022000" X2="2.450000" Y2="-2.818000"
        Z2="5.005000"/>
        <NavigationToTransducer X="0.757000" Y="7.014000" Z="27.360000" X2="1.061000"
        Y2="7.119000" Z2="27.343000"/>
        <Transducer Roll="0.000000" Roll2="0.000000"/>
        <Navigation Latency="0.000000"/>
      </Offsets>
      <StandardDeviation>
        <Motion Gyro="0.015000" HeavePercAmplitude="0.000000" Heave="0.000000" Roll="0.003000"
        Pitch="0.003000" PitchStablized="0.000000"/>
        <Position Navigation="0.100000"/>
        <Timing Transducer="0.001000" Navigation="0.001000" Gyro="0.001000" Heave="0.001000"
        Pitch="0.001000" Roll="0.001000"/>
        <SoundVelocity Measured="0.000000" Surface="0.000000"/>
        <Tide Measured="0.000000" Zoning="0.000000"/>
        <Offsets X="0.002000" Y="0.002000" Z="0.002000"/>
        <MRUAlignment Gyro="0.030000" Pitch="0.060000" Roll="0.060000"/>
        <Vessel Speed="0.000000" Loading="0.000000" Draft="0.000000" DeltaDraft="0.000000">
          <StDevComment value="(null)"/>
        </Vessel>
      </StandardDeviation>
    </TimeStamp>
  </TPEConfiguration>
</HIPSVesselConfig>
```

```
Vessel Name: TJ_S222_Klein5000_SSS100_2017.hvf
Vessel created: January 23, 2018


Depth Sensor:

    Sensor Class:    Swath
    Time Stamp:  2015-001 00:00

    Comments:
    Time Correction(s) 0.000

    Transduer #1:
    -------------
    Pitch Offset:   0.000
    Roll Offset:    0.000
    Azimuth Offset: 0.000

    DeltaX: 0.000
    DeltaY: 0.000
    DeltaZ: 0.000

    Manufacturer:
    Model:       Unknown
    Serial Number:

___________________________________________________________
Navigation Sensor:

    Time Stamp:  2015-001 00:00

    Comments: (null)
    Time Correction(s) -3.200
    DeltaX: 0.000
    DeltaY: 0.000
    DeltaZ: 0.000

    Manufacturer:    Applanix
    Model:       v4
    Serial Number:   (null)

___________________________________________________________
Heave Sensor:

    Time Stamp:  2015-001 00:00

    Comments: (null)
    Apply No
    Time Correction(s) 0.000
    DeltaX: 0.000
    DeltaY: 0.000
    DeltaZ: 0.000
    Offset: 0.000

    Manufacturer:    (null)
    Model:       (null)
    Serial Number:   (null)

___________________________________________________________
Pitch Sensor:

    Time Stamp:  2015-001 00:00

    Comments: (null)
```

```
    Apply No
    Time Correction(s) 0.000
    Pitch offset: 0.000

    Manufacturer:    (null)
    Model:       (null)
    Serial Number:   (null)
```

```
Roll Sensor:

    Time Stamp:  2015-001 00:00

    Comments: (null)
    Apply No
    Time Correction(s) 0.000
    Roll offset: 0.000

    Manufacturer:    (null)
    Model:       (null)
    Serial Number:   (null)
```

```
Tow Point:

    Time Stamp:  2015-001 00:00

    Comments: HSRR 2015
    Time Correction(s) 0.000
    DeltaX: 6.370
    DeltaY: -42.550
    DeltaZ: -4.800

    Manufacturer:    Klein
    Model:       5000 V2
    Serial Number:


    Time Stamp:  2015-117 00:00

    Comments: HSRR 2015 SSS Cert Results
    Time Correction(s) 0.000
    DeltaX: 6.370
    DeltaY: -42.550
    DeltaZ: -4.800

    Manufacturer:    Klein
    Model:       5000 V2
    Serial Number:
```

```
WaterLine:

    Time Stamp:  2015-001 00:00

    Comments: HSRR 2015
    Apply Yes
    WaterLine 0.380

    Time Stamp:  2015-166 00:00

    Comments: With HSL's, after ballasting during Charleston port call.
    Apply Yes
    WaterLine 0.441
```

```
Vessel Name: TJ_S222_Klein5000_SSS200_2017.hvf
Vessel created: January 23, 2018


Depth Sensor:

    Sensor Class:    Swath
    Time Stamp:  2015-001 00:00

    Comments:
    Time Correction(s) 0.000

    Transduer #1:
    -------------
    Pitch Offset:   0.000
    Roll Offset:    0.000
    Azimuth Offset: 0.000

    DeltaX: 0.000
    DeltaY: 0.000
    DeltaZ: 0.000

    Manufacturer:
    Model:       Unknown
    Serial Number:
```

```
Navigation Sensor:

    Time Stamp:  2015-001 00:00

    Comments: (null)
    Time Correction(s) -3.200
    DeltaX: 0.000
    DeltaY: 0.000
    DeltaZ: 0.000

    Manufacturer:    Applanix
    Model:       v4
    Serial Number:   (null)
```

```
Heave Sensor:

    Time Stamp:  2015-001 00:00

    Comments: (null)
    Apply No
    Time Correction(s) 0.000
    DeltaX: 0.000
    DeltaY: 0.000
    DeltaZ: 0.000
    Offset: 0.000

    Manufacturer:    (null)
    Model:       (null)
    Serial Number:   (null)
```

```
Pitch Sensor:

    Time Stamp:  2015-001 00:00

    Comments: (null)
```

```
    Apply No
    Time Correction(s) 0.000
    Pitch offset: 0.000

    Manufacturer:    (null)
    Model:       (null)
    Serial Number:   (null)
```

```
Roll Sensor:

    Time Stamp:  2015-001 00:00

    Comments: (null)
    Apply No
    Time Correction(s) 0.000
    Roll offset: 0.000

    Manufacturer:    (null)
    Model:       (null)
    Serial Number:   (null)
```

```
Tow Point:

    Time Stamp:  2015-001 00:00

    Comments: HSRR 2015
    Time Correction(s) 0.000
    DeltaX: 6.370
    DeltaY: -42.550
    DeltaZ: -4.800

    Manufacturer:    Klein
    Model:       5000 V2
    Serial Number:


    Time Stamp:  2015-117 00:00

    Comments: HSRR 2015 SSS Cert Results
    Time Correction(s) 0.000
    DeltaX: 6.370
    DeltaY: -42.550
    DeltaZ: -4.800

    Manufacturer:    Klein
    Model:       5000 V2
    Serial Number:
```

```
WaterLine:

    Time Stamp:  2015-001 00:00

    Comments: HSRR 2015
    Apply Yes
    WaterLine 0.380

    Time Stamp:  2015-166 00:00

    Comments: With HSL's, after ballasting during Charleston port call.
    Apply Yes
    WaterLine 0.441
```

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Office of Marine and Aviation Operations,
Marine Operation Center-Atlantic, NOAA Ship Thomas Jefferson
Norfolk, Virginia 23510

August 3, 2017

MEMORANDUM FOR: Captain Richard T. Brennan, NOAA
Chief, Hydrographic Surveys Division

FROM: Commander Chris Van Westendorp, NOAA
Commanding Officer, NOAA Ship Thomas Jefferson

SUBJECT: NOAA Ship Thomas Jefferson Hydrographic Systems Status Summary

The hydrographic systems of NOAA Ship *Thomas Jefferson* were reviewed in accordance with the Office of Coast Survey Field Procedures Manual (FPM) Hydrographic Systems Readiness Review procedures. *Thomas Jefferson* ran system certification operations off of Capes Henry and Charles in July of 2017.

All certification tests were conducted and reviewed by a Hydrographic Systems Review Team comprised of the following people:

LT Matthew Forrest, Operations Officer;
LT Anthony Klemm, Operations Officer in Training
Acting Chief Hydrographic Survey Technician Allison Stone
Clinton Marcus, Physical Scientist, Atlantic Hydrographic Branch
John Doroba, Physical Scientist, Hydrographic Systems and Technology Branch
Glen Rice, Physical Scientist, Hydrographic Systems and Technology Branch
Thomas Jefferson's Survey Department
Thomas Jefferson's Junior Officers.

The team installed and tested all systems except as noted below. The appropriate calibrations, checks, and tests have been performed, and all tested satisfactorily except as noted below.

The Review Team's findings are summarized in this memorandum and reflect the condition of the *Thomas Jefferson*'s hydrographic systems on the review date. These findings have been divided into three categories of deficiencies:

CATEGORY 1 – These deficiencies indicate the failure or absence of vital equipment or preparations of systems essential to acquisition and/or processing of hydrographic data. The vessel will be required to cease or limit hydrographic survey operations due to the following deficiencies:

There are no Category 1 deficiencies.

CATEGORY 2 – These deficiencies indicate noncompliance with established policies, directives, instructions, or accepted hydrographic practice not addressed under Category The following deficiencies shall be corrected in as timely a manner as funding, time, and/or professional assistance permit:

1. The ship's Kongsberg EM710 and EM2040 multibeam echosounders continue to operate in a degraded mode for normal hydrographic survey operations. HSTB has issued guidance recommending limiting the EM710 and EM2040 to a 90° swath width to minimize the impact of an outer beam artifact. The source is as yet unknown, but is suspected to be bubble sweepdown or another oceanographic influence. Limiting the swath minimizes the appearance of the artifact, but severely limits the capability of both systems to operate as intended. The most pronounced effect of this limitation on day-to-day operations is the lack of coverage of the Side Scan Sonar nadir gap in shallower water.
2. The ship's Side Scan Sonar's certification revealed a 2 second offset from the POS M/V-supplied timestamp to its internal timestamp. This is a new issue, and the source of it eludes the entire HSRR team. While an offset in post-processing has largely solved the issue, it is a distinct possibility that the system is showing signs of age and need of upgrading, repairs, or replacement.

CATEGORY 3 – These deficiencies are associated with observations during the course of the review which merit consideration for corrective actions. These observations are included for review and dialogue related to potential problem areas and hydrographic operational efficiency. It is important to assure that resources (funds, skills, and time) are available at the operating level in order to meet the needs identified in this report and to sustain the ef ficient operation, upkeep, and repair of the field unit's hydrographic systems.

1. The ship's Moving Vessel Profiler (MVP) is showing signs of age. At present, the MVP functions adequately, but is no longer supported by the manufacturer and has fairly significant external corrosion. Additionally, its cable is down to 160m, of which 120m is usable, a far cry from its original 200m length. Its replacement as soon as funds are available is requested.
2. The ship's Side Scan Sonar winch is well past its useful life. Parts are becoming more scarce as time goes on, and preservation of it against the corrosion that has already set in will be a major undertaking by deck department. Its replacement as soon as funds are available is requested.

Items not completed are below. They were skipped over owing to an extremely short HSRR period, tardy launch delivery and warranty work-related delays, and the Command's prioritization of ship system readiness. They will be completed later in the season when launch work is called for.

HSL 2903:

- Patch Test
- Side Scan Certification
- CTD Comparison
- GAMS calibration
- Ellipsoidally Referenced Dynamic Draft
- Multibeam Patch Test: 200/400 khz
- Reference Surface: 200/400 khz
- Multibeam vs Vertical beam vs leadline comparison
- Side Scan Sonar Calibration: 50/75/100 meters
-

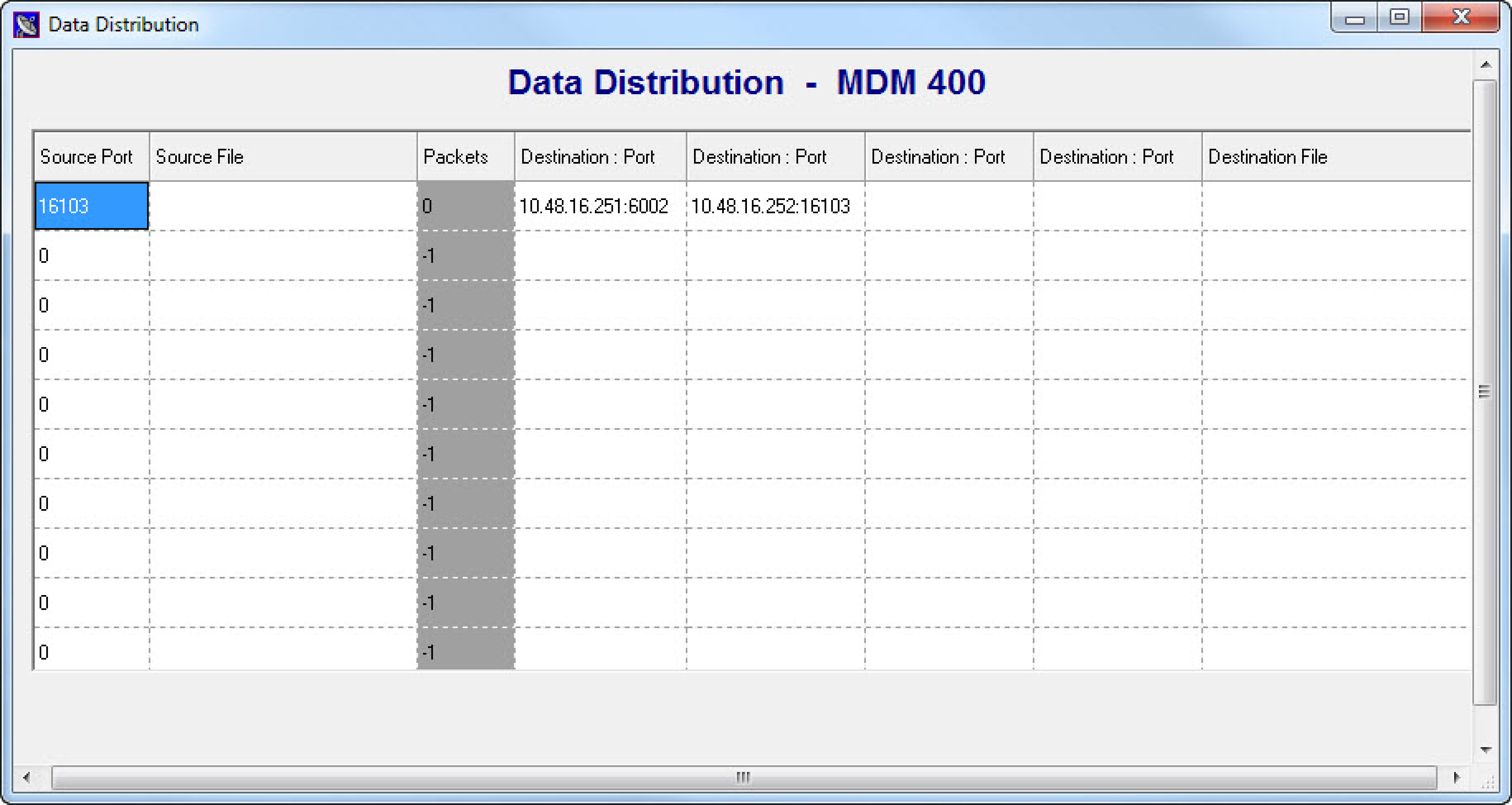
HSL 2904:

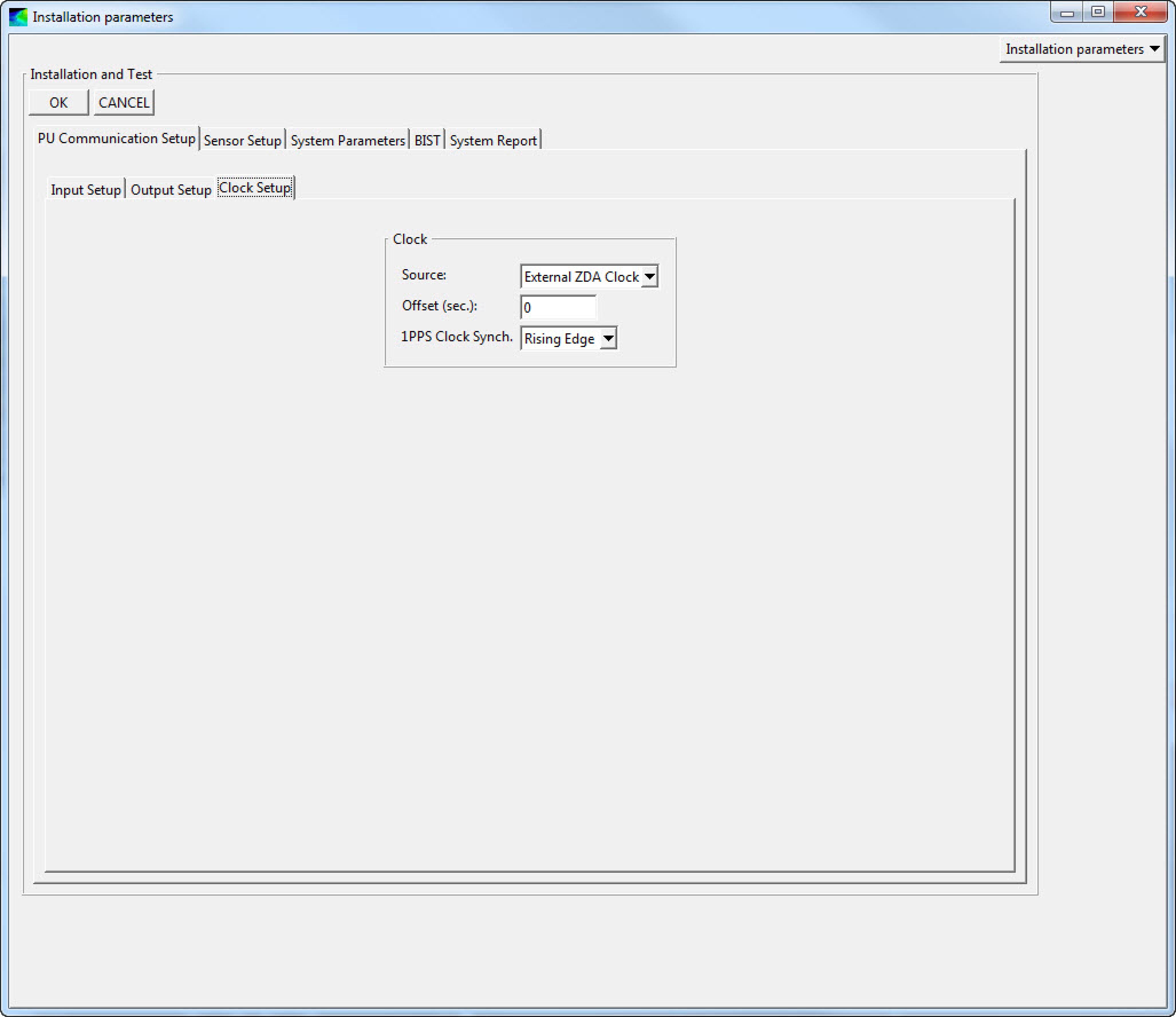
- Patch Test
- Side Scan Certification

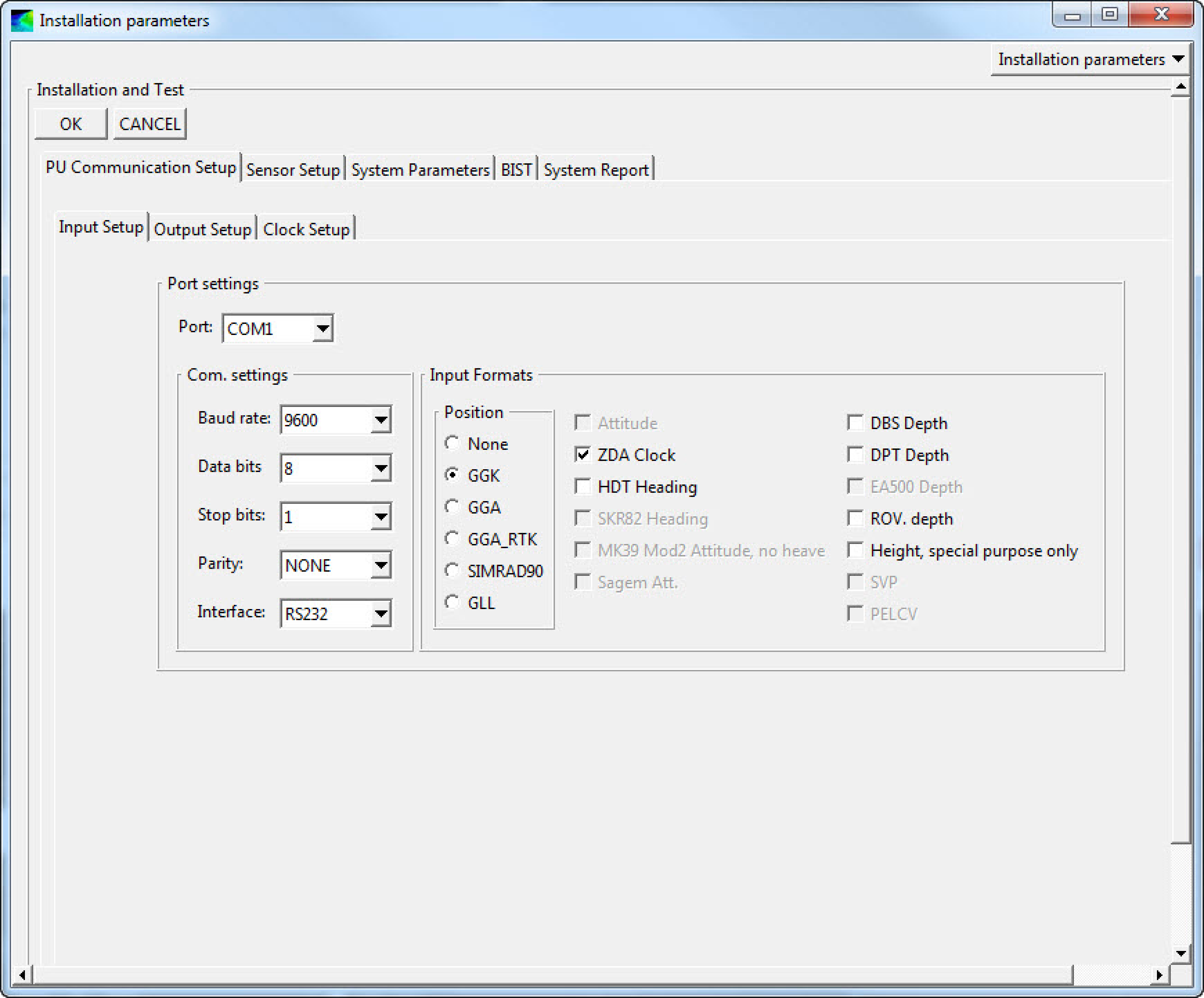
- CTD Comparison
- GAMS calibration
- Ellipsoidally Referenced Dynamic Draft
- Multibeam Patch Test: 200/400 khz
- Reference Surface: 200/400 khz
- Multibeam vs Vertical beam vs leadline comparison
- Side Scan Sonar Calibration: 50/75/100 meters

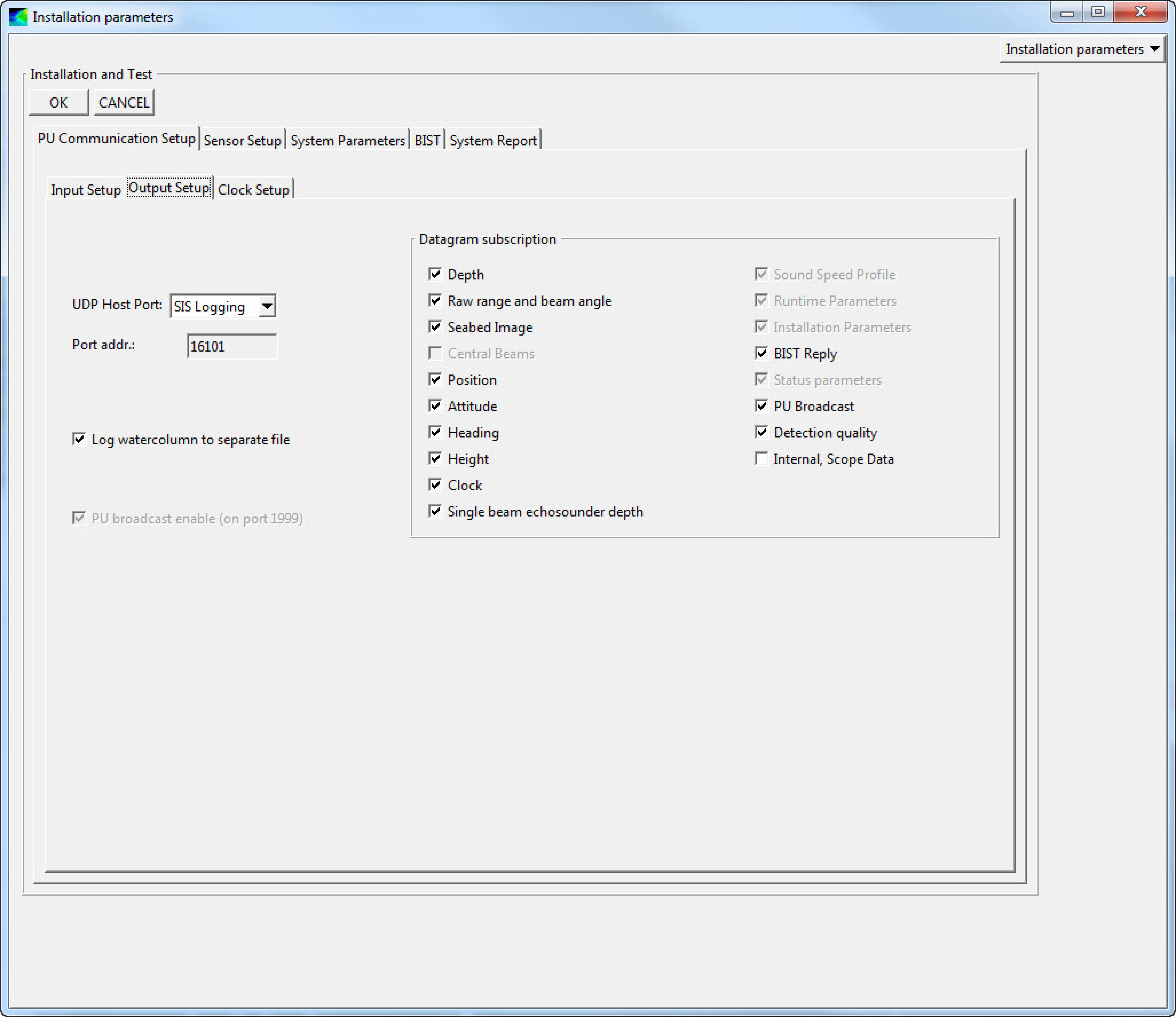
Z-1:
- Static draft
- Dynamic draft
- Bar check
- Latency check
- Reference surface: compared to 200 khz on HSLs

Z-2:
- Static draft
- Dynamic draft
- Bar check
- Latency check
- Reference surface: compared to 200 khz on HSLs


Data Distribution
Data Distribution - MDM 400
Source Port
Source File
Packets
Destination : Port
Destination : Port
Destination : Port
Destination : Port
Destination File
16103
0
10.48.16.251:6002
10.48.16.252:16103
0
-1
0
-1
0
-1
0
-1
0
-1
0
-1
0
-1
0
-1
0
-1


Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
Clock
Source:
External ZDA Clock
Offset (sec.):
0
1PPS Clock Synch.
Rising Edge


Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
Port settings
Port: COM1
Com. settings
Baud rate: 9600
Data bits 8
Stop bits: 1
Parity: NONE
Interface: RS232
Input Formats
Position
None
GGK
GGA
GGA_RTK
SIMRAD90
GLL
Attitude
ZDA Clock
HDT Heading
SKR82 Heading
MK39 Mod2 Attitude, no heave
Sagem Att.
DBS Depth
DPT Depth
EA500 Depth
ROV. depth
Height, special purpose only
SVP
PELCV


Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
UDP Host Port:
SIS Logging
Port addr.:
16101
Log watercolumn to separate file
PU broadcast enable (on port 1999)
Datagram subscription
Depth
Raw range and beam angle
Seabed Image
Central Beams
Position
Attitude
Heading
Height
Clock
Single beam echosounder depth
Sound Speed Profile
Runtime Parameters
Installation Parameters
BIST Reply
Status parameters
PU Broadcast
Detection quality
Internal, Scope Data

Installation parameters

Installation parameters

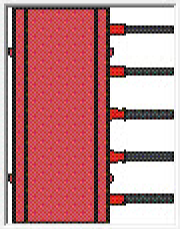
Installation and Test

OK CANCEL

PU Communication Setup | Sensor Setup | System Parameters | BIST | System Report

Settings | Locations | Angular Offsets | ROV. Specific

TX Transducer Orient.

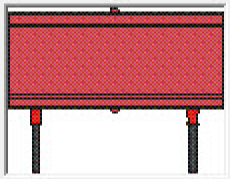


Port

Starb.

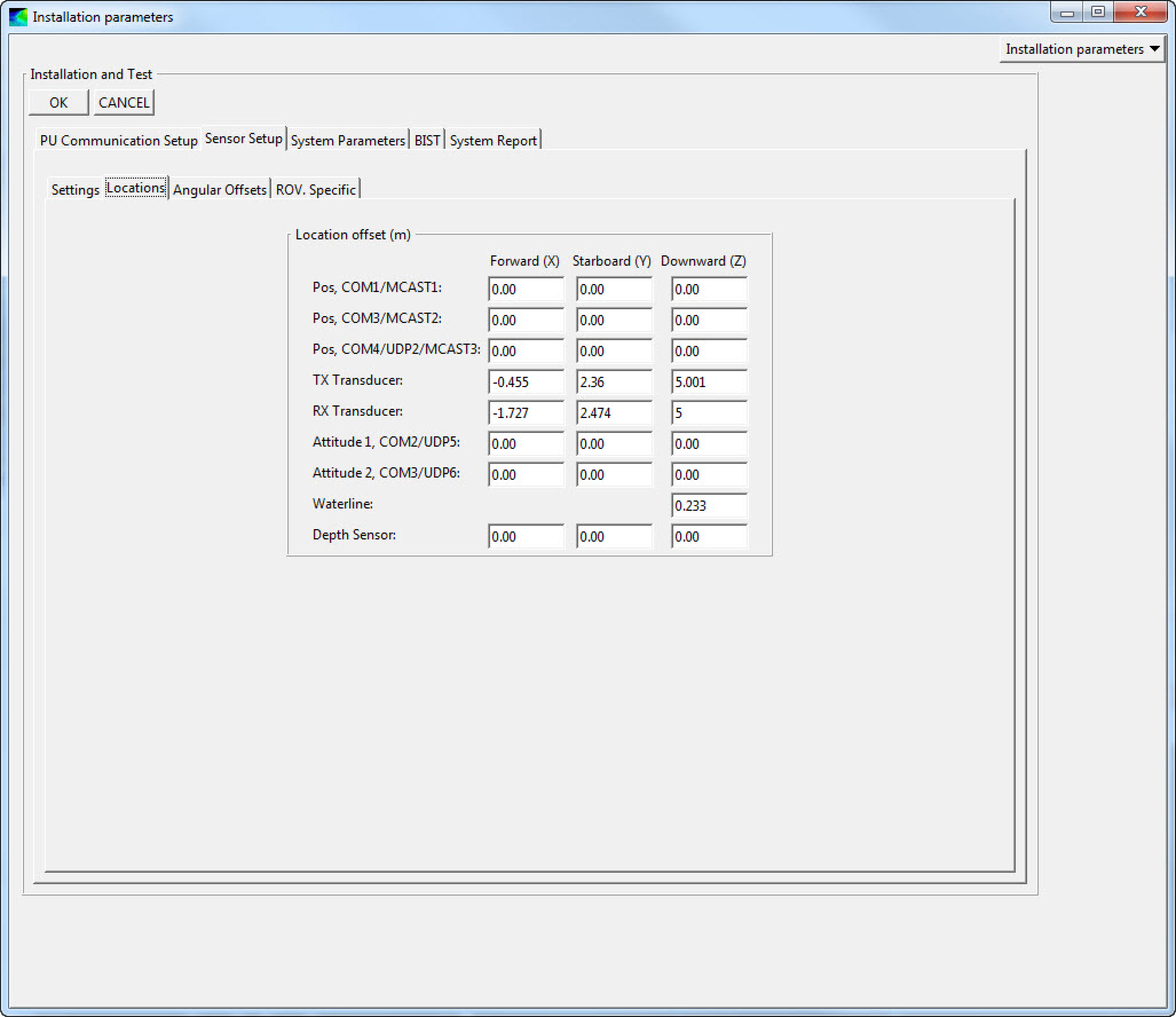
RX Transducer Orient.

Forw. Aft

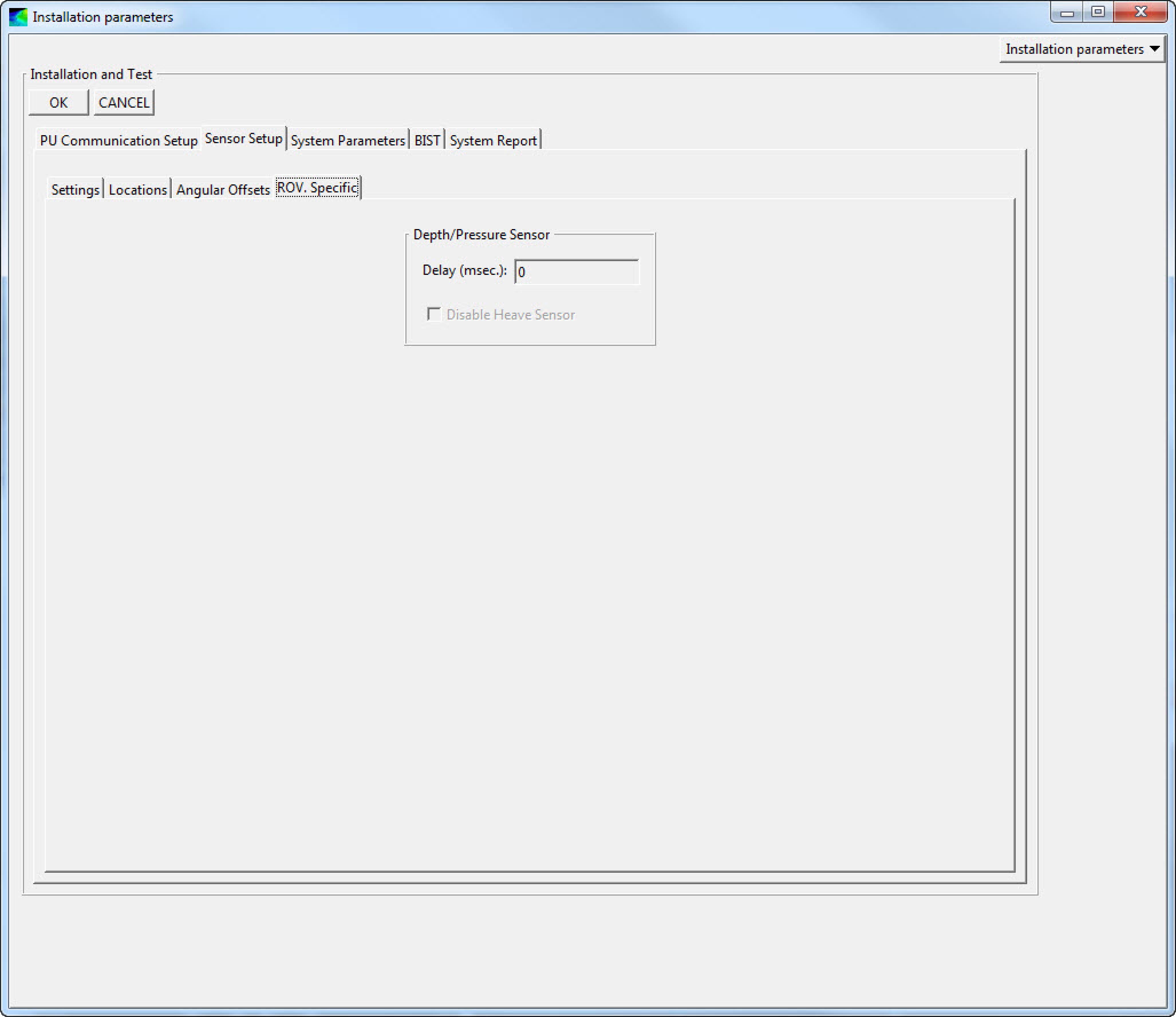


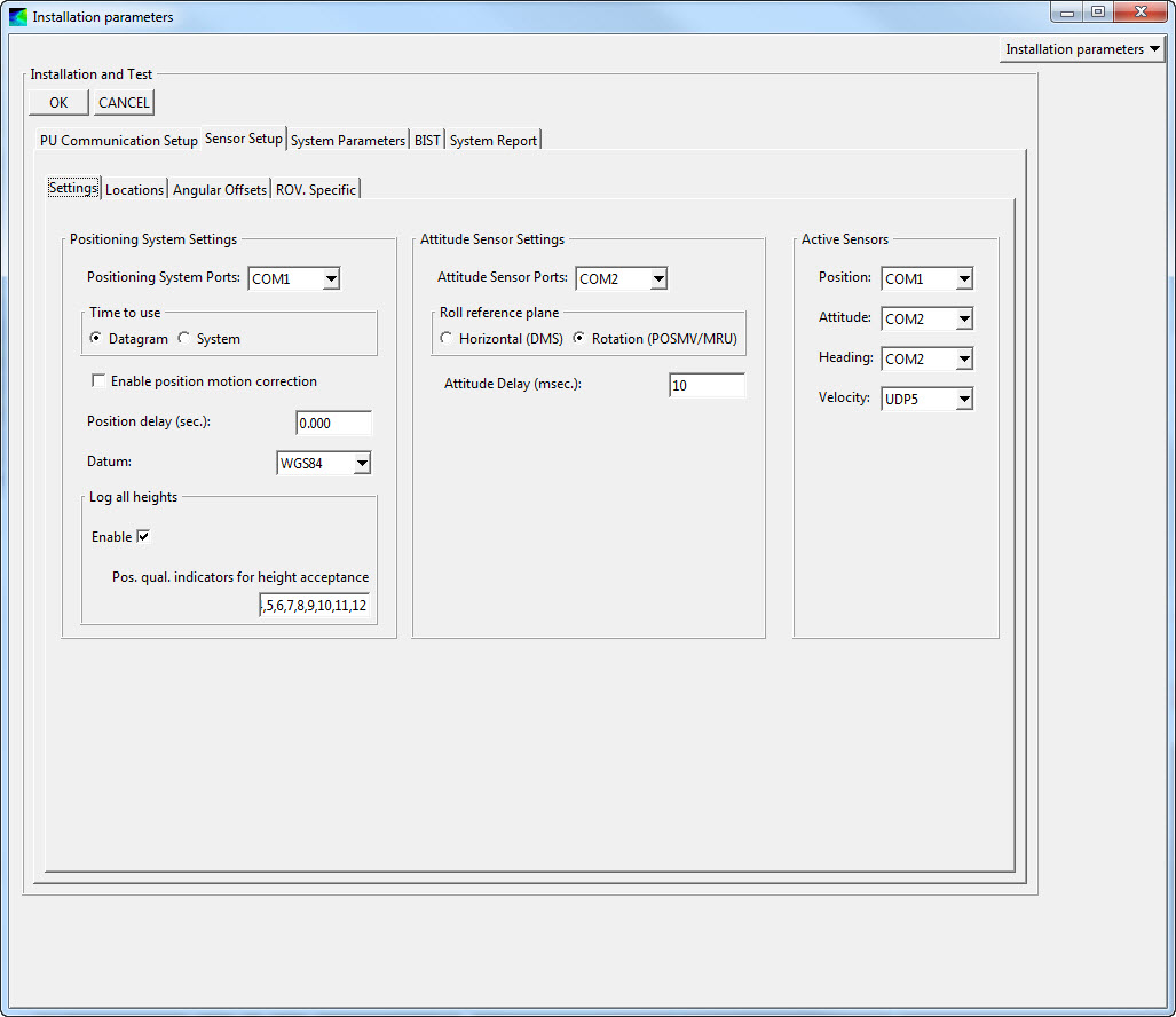
Offset angles (deg.)

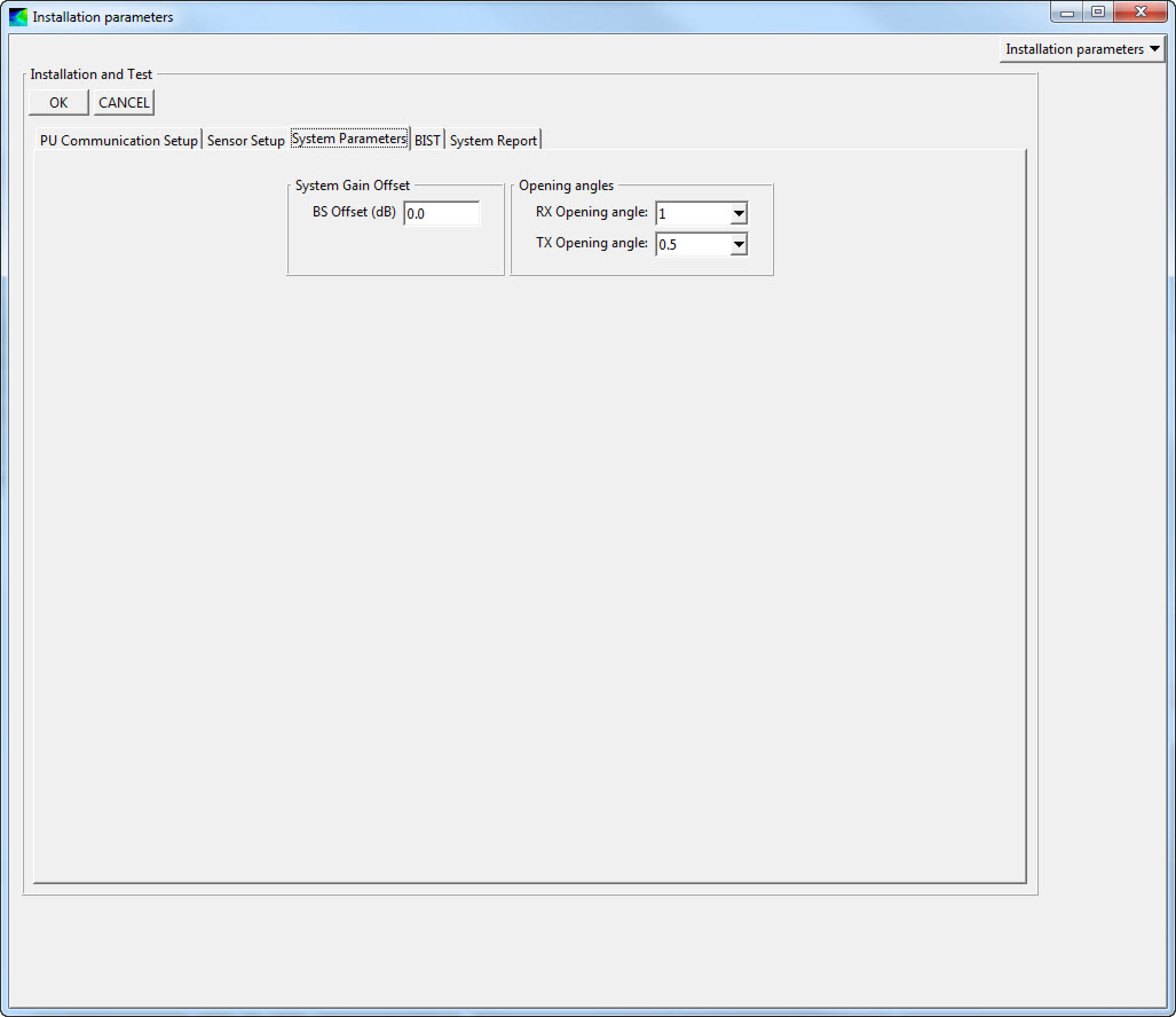
	Roll	Pitch	Heading
TX Transducer:	-0.25206	0.08796	359.302
RX Transducer:	-0.17725	0.17330	359.576
Attitude 1, COM2/UDP5:	-0.01	0.14	0.02
Attitude 2, COM3/UDP6:	0.00	0.00	0.00
Stand-alone Heading:			0.00



Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Settings
Locations
Angular Offsets
ROV. Specific
Location offset (m)
Forward (X)
Starboard (Y)
Downward (Z)
Pos, COM1/MCAST1: 0.00 0.00 0.00
Pos, COM3/MCAST2: 0.00 0.00 0.00
Pos, COM4/UDP2/MCAST3: 0.00 0.00 0.00
TX Transducer: -0.455 2.36 5.001
RX Transducer: -1.727 2.474 5
Attitude 1, COM2/UDP5: 0.00 0.00 0.00
Attitude 2, COM3/UDP6: 0.00 0.00 0.00
Waterline: 0.233
Depth Sensor: 0.00 0.00 0.00


Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Settings
Locations
Angular Offsets
ROV. Specific
Depth/Pressure Sensor
Delay (msec.):
0
Disable Heave Sensor

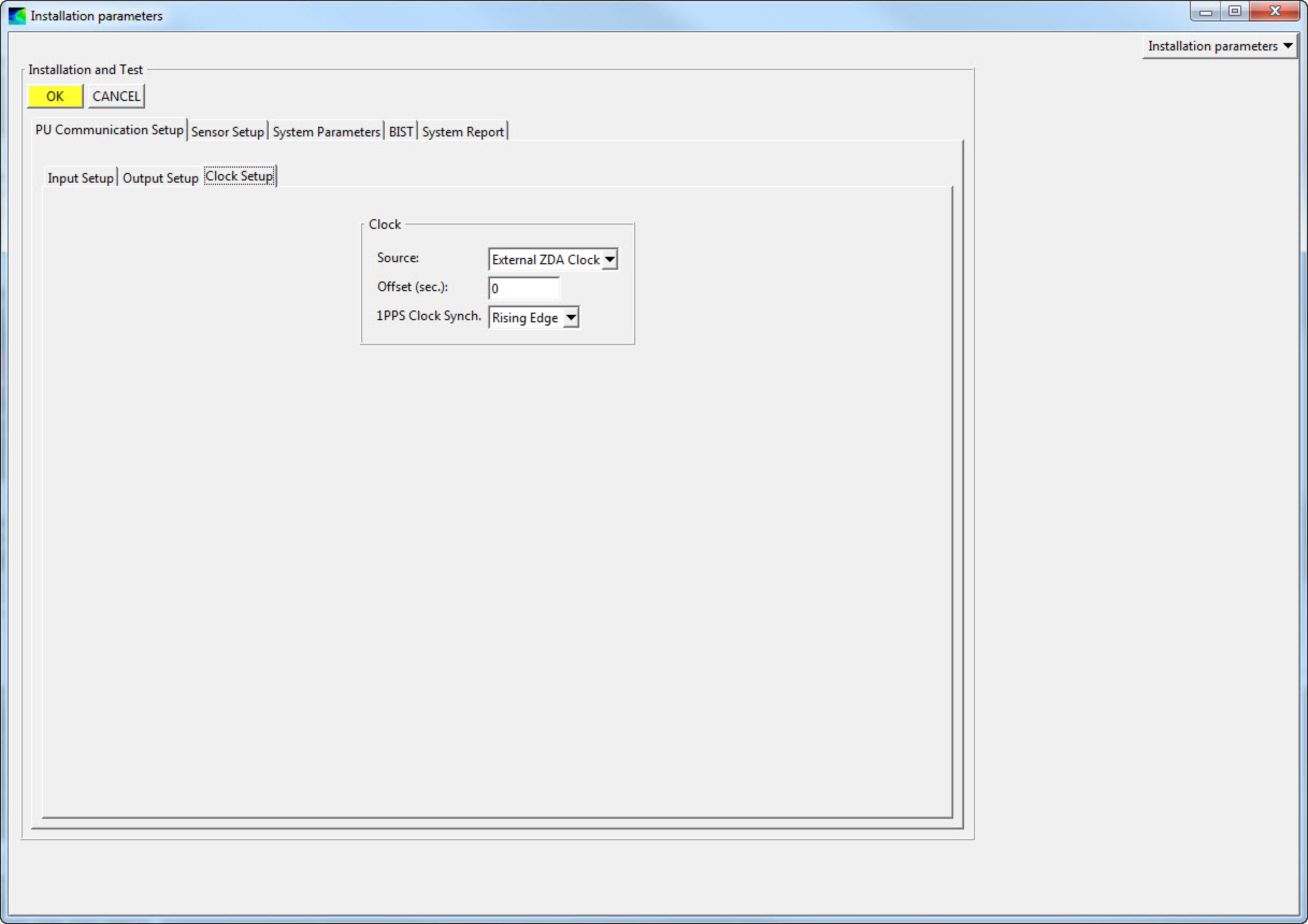

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Settings
Locations
Angular Offsets
ROV. Specific
Positioning System Settings
Positioning System Ports:
COM1
Time to use
Datagram
System
Enable position motion correction
Position delay (sec.):
0.000
Datum:
WGS84
Log all heights
Enable
Pos. qual. indicators for height acceptance
,5,6,7,8,9,10,11,12
Attitude Sensor Settings
Attitude Sensor Ports:
COM2
Roll reference plane
Horizontal (DMS)
Rotation (POSMV/MRU)
Attitude Delay (msec.):
10
Active Sensors
Position:
COM1
Attitude:
COM2
Heading:
COM2
Velocity:
UDP5

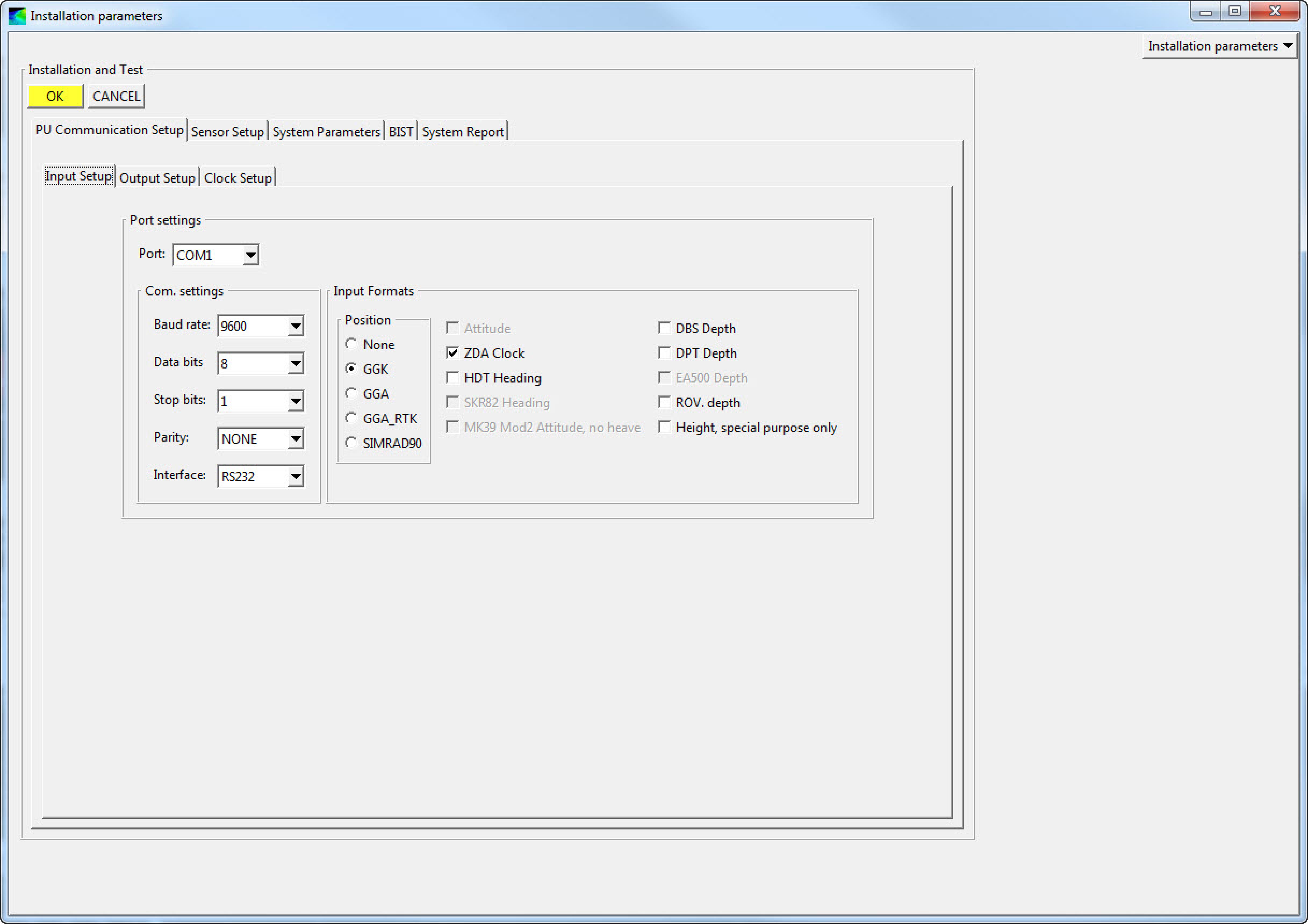

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
System Gain Offset
BS Offset (dB)
0.0
Opening angles
RX Opening angle:
1
TX Opening angle:
0.5

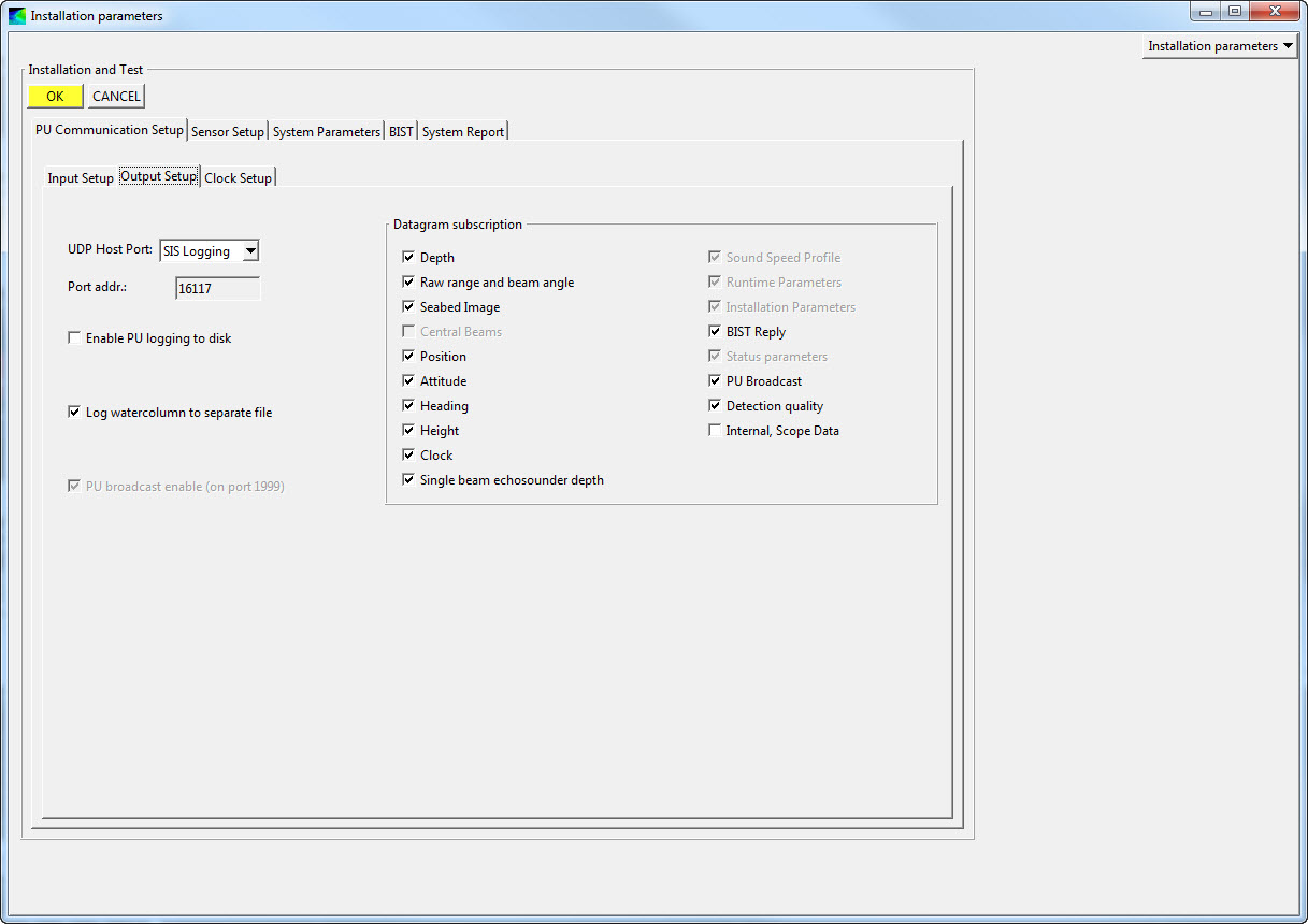
Data Distribution

Data Distribution - MDM 400

Source Port	Source File	Packets	Destination : Port	Destination : Port	Destination : Port	Destination : Port	Destination File
16119		0	10.48.16.251:6001	10.48.16.252:16103			
0		-1					
0		-1					
0		-1					
0		-1					
0		-1					
0		-1					
0		-1					
0		-1					
0		-1					


Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
Clock
Source:
External ZDA Clock
Offset (sec.):
0
1PPS Clock Synch.
Rising Edge


Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
Port settings
Port:
COM1
Com. settings
Baud rate:
9600
Data bits
8
Stop bits:
1
Parity:
NONE
Interface:
RS232
Input Formats
Position
None
GGK
GGA
GGA_RTK
SIMRAD90
Attitude
ZDA Clock
HDT Heading
SKR82 Heading
MK39 Mod2 Attitude, no heave
DBS Depth
DPT Depth
EA500 Depth
ROV. depth
Height, special purpose only


Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Input Setup
Output Setup
Clock Setup
UDP Host Port:
SIS Logging
Port addr.:
16117
Enable PU logging to disk
Log watercolumn to separate file
PU broadcast enable (on port 1999)
Datagram subscription
Depth
Raw range and beam angle
Seabed Image
Central Beams
Position
Attitude
Heading
Height
Clock
Single beam echosounder depth
Sound Speed Profile
Runtime Parameters
Installation Parameters
BIST Reply
Status parameters
PU Broadcast
Detection quality
Internal, Scope Data

Installation parameters

Installation parameters

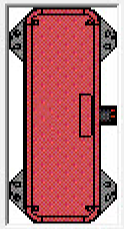
Installation and Test

OK | CANCEL

PU Communication Setup | Sensor Setup | System Parameters | BIST | System Report

Settings | Locations | Angular Offsets | ROV. Specific

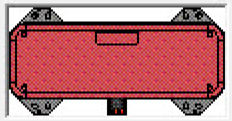
TX Transducer Orient.



( ) Port
(•) Starb.

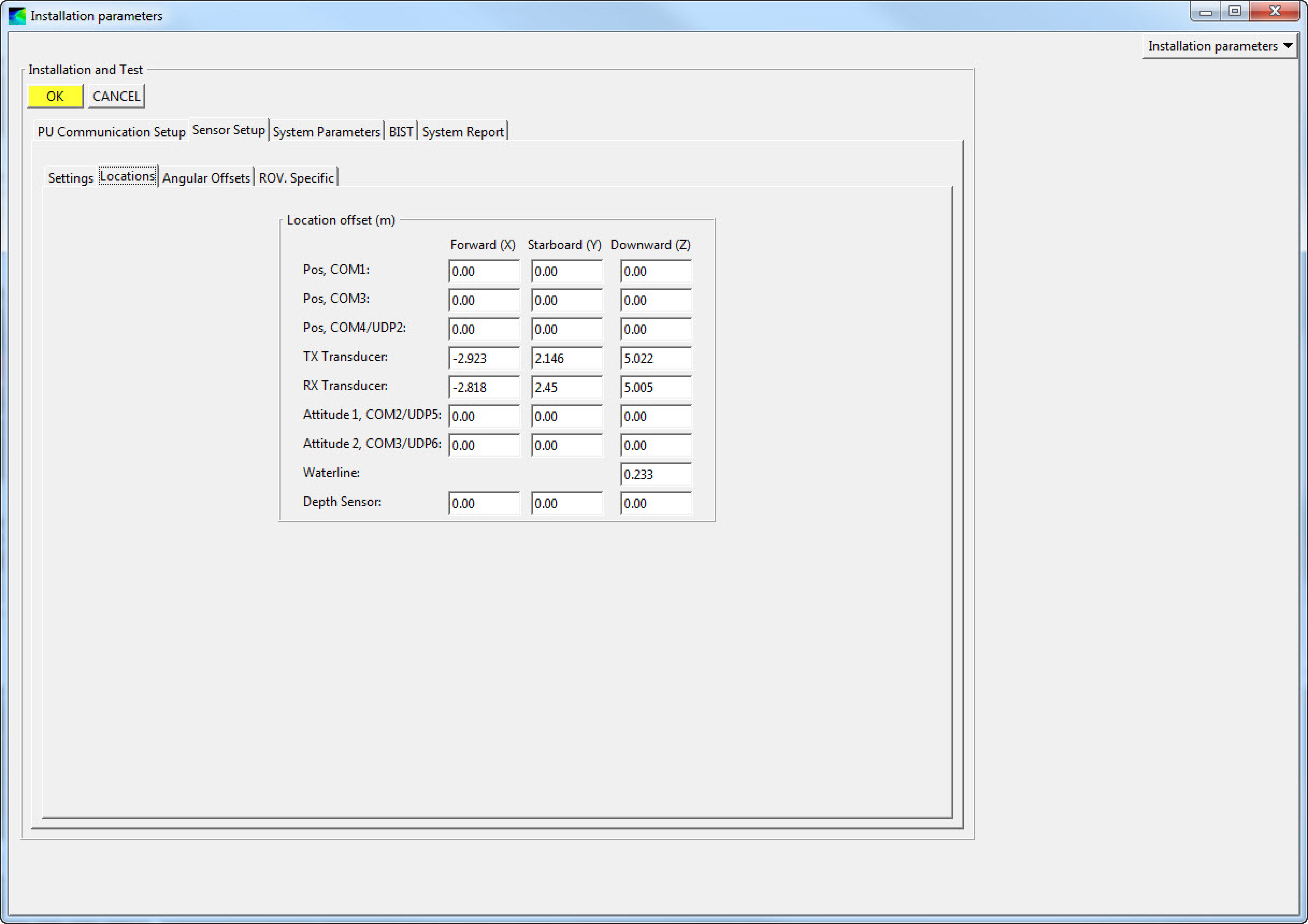
RX Transducer Orient.

( ) Forw. (•) Aft

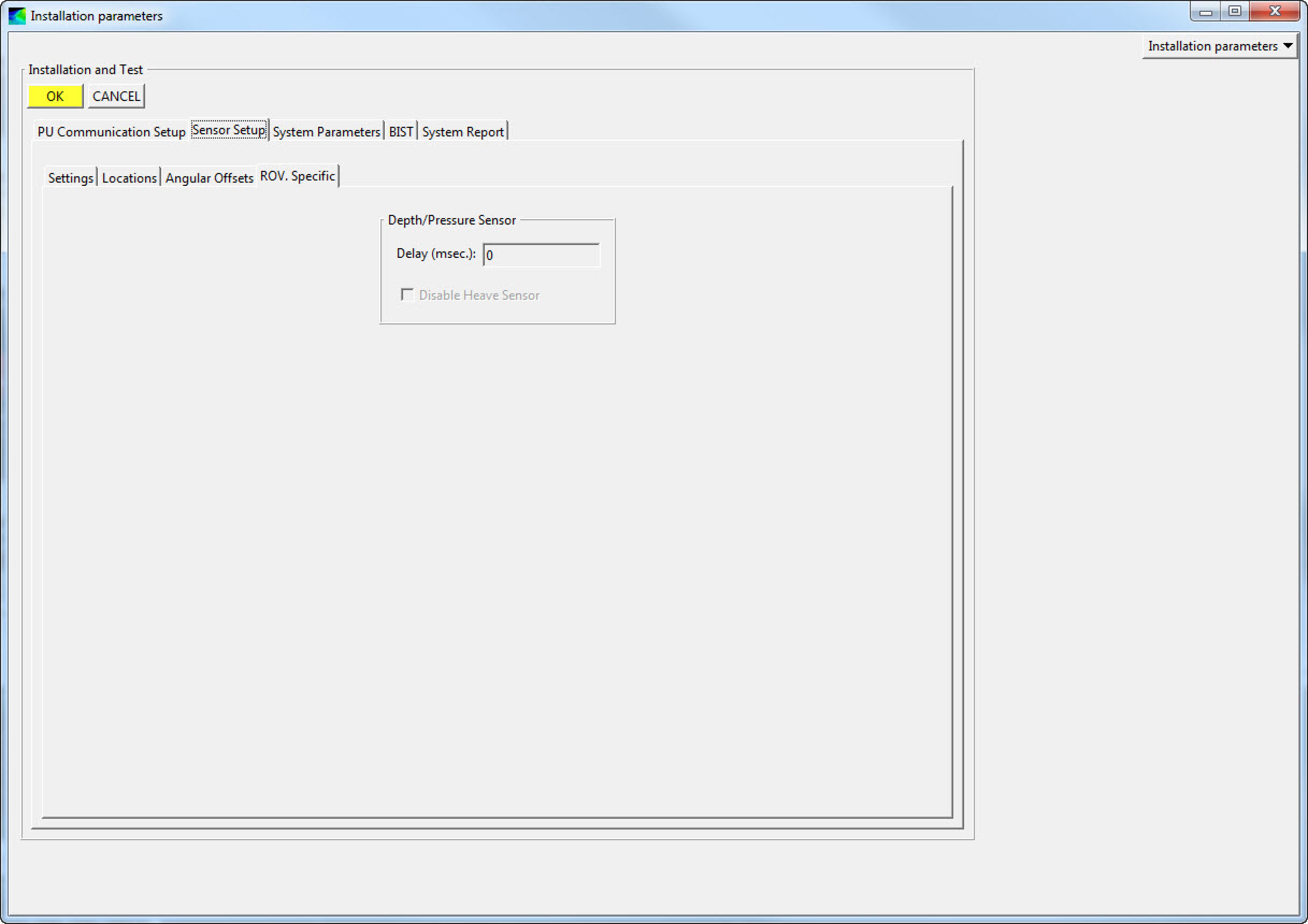


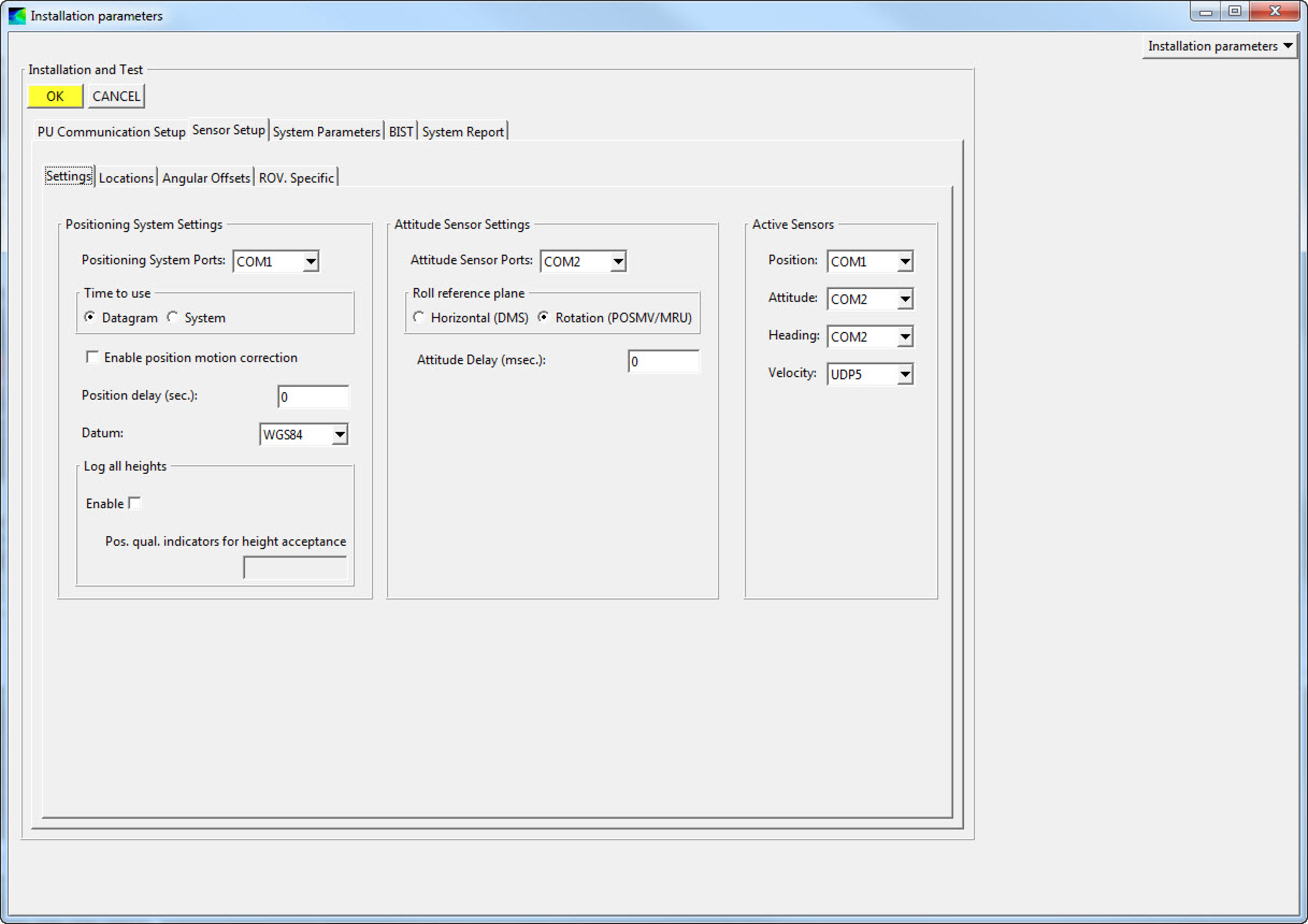
Offset angles (deg.)

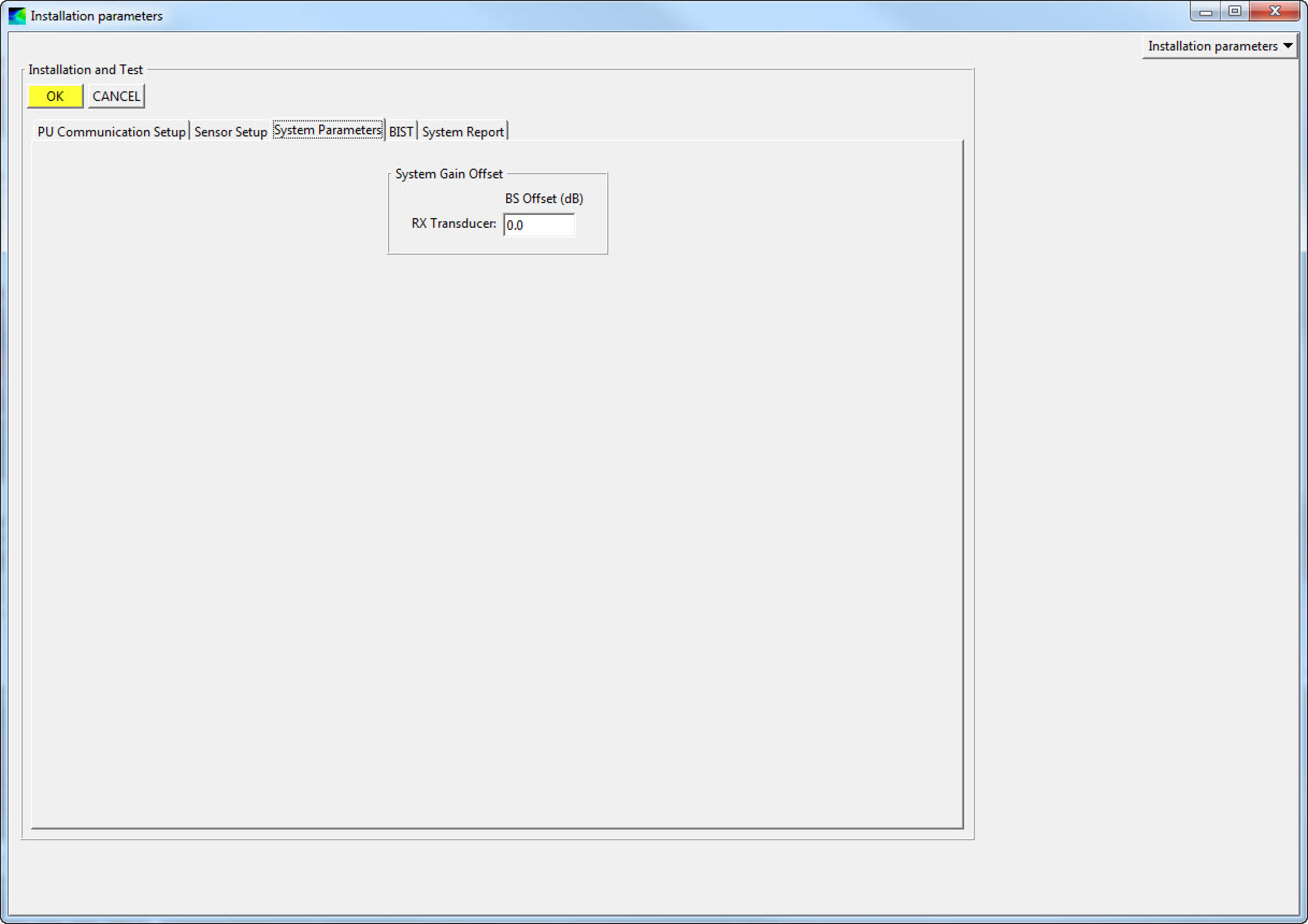
	Roll	Pitch	Heading
TX Transducer:	-0.32704	0.26602	359.50389
RX Transducer:	-0.41885	0.27675	359.49823
Attitude 1, COM2/UDP5:	-0.04	0.01	0.24
Attitude 2, COM3/UDP6:	0.00	0.00	0.00
Stand-alone Heading:			0.00

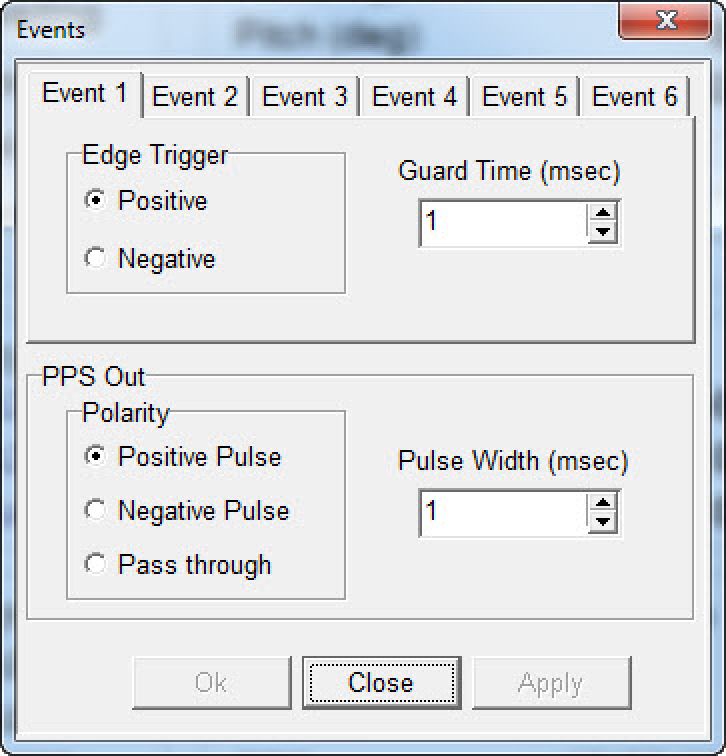


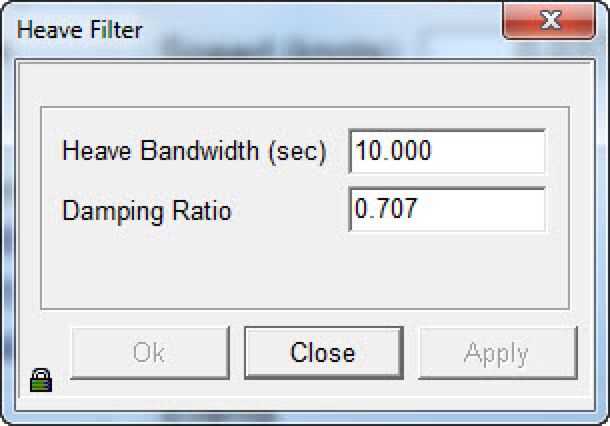
Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Settings
Locations
Angular Offsets
ROV. Specific
Location offset (m)
Forward (X)
Starboard (Y)
Downward (Z)
Pos, COM1: 0.00 0.00 0.00
Pos, COM3: 0.00 0.00 0.00
Pos, COM4/UDP2: 0.00 0.00 0.00
TX Transducer: -2.923 2.146 5.022
RX Transducer: -2.818 2.45 5.005
Attitude 1, COM2/UDP5: 0.00 0.00 0.00
Attitude 2, COM3/UDP6: 0.00 0.00 0.00
Waterline: 0.233
Depth Sensor: 0.00 0.00 0.00

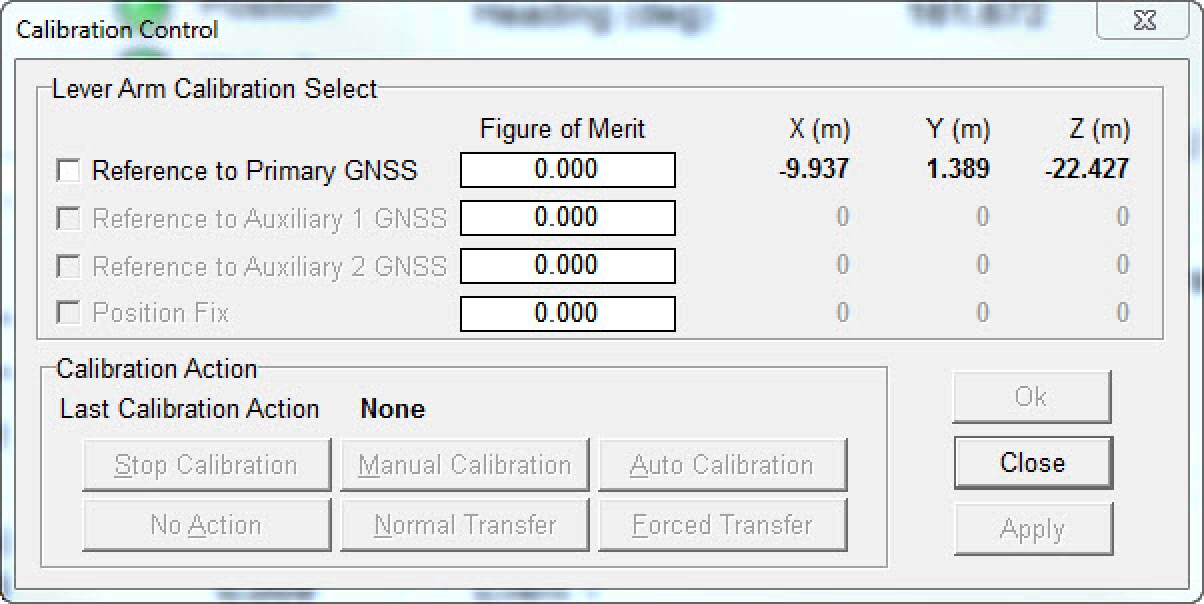

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Settings
Locations
Angular Offsets
ROV. Specific
Depth/Pressure Sensor
Delay (msec.):
0
Disable Heave Sensor

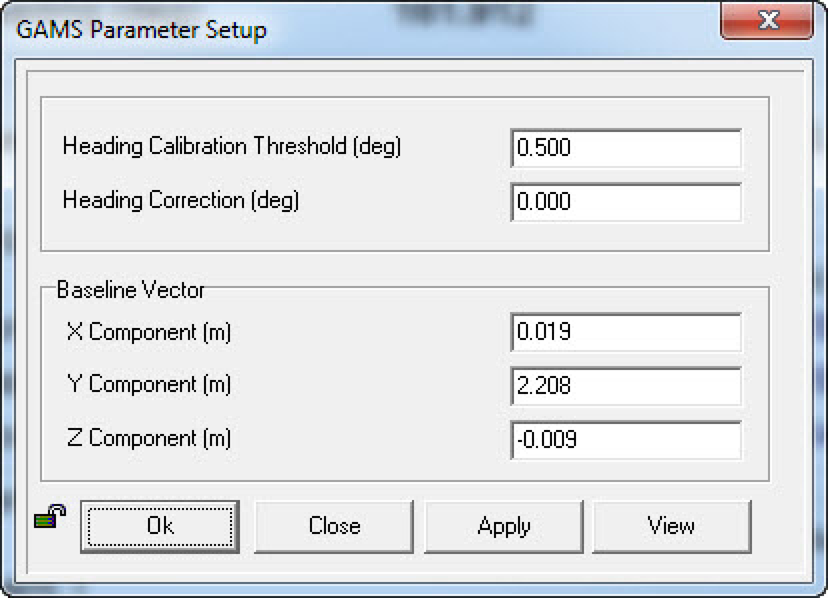

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Settings
Locations
Angular Offsets
ROV. Specific
Positioning System Settings
Positioning System Ports: COM1
Time to use
Datagram
System
Enable position motion correction
Position delay (sec.): 0
Datum: WGS84
Log all heights
Enable
Pos. qual. indicators for height acceptance
Attitude Sensor Settings
Attitude Sensor Ports: COM2
Roll reference plane
Horizontal (DMS)
Rotation (POSMV/MRU)
Attitude Delay (msec.): 0
Active Sensors
Position: COM1
Attitude: COM2
Heading: COM2
Velocity: UDP5

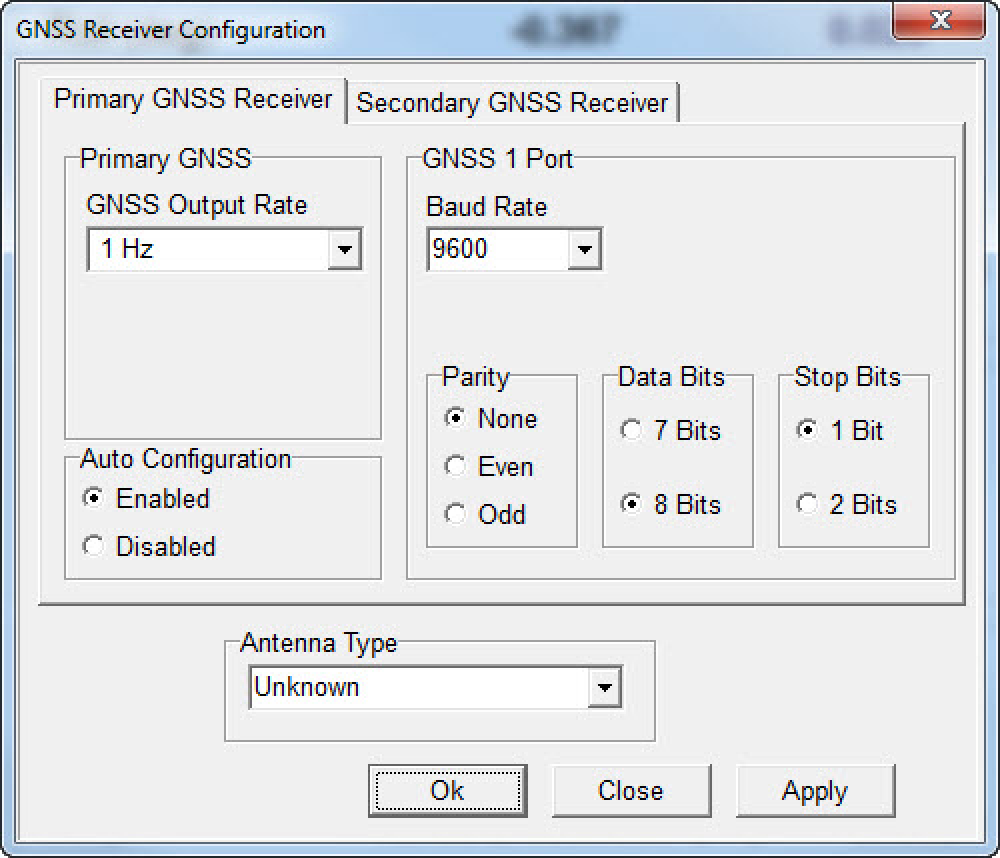

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
System Gain Offset
BS Offset (dB)
RX Transducer:
0.0

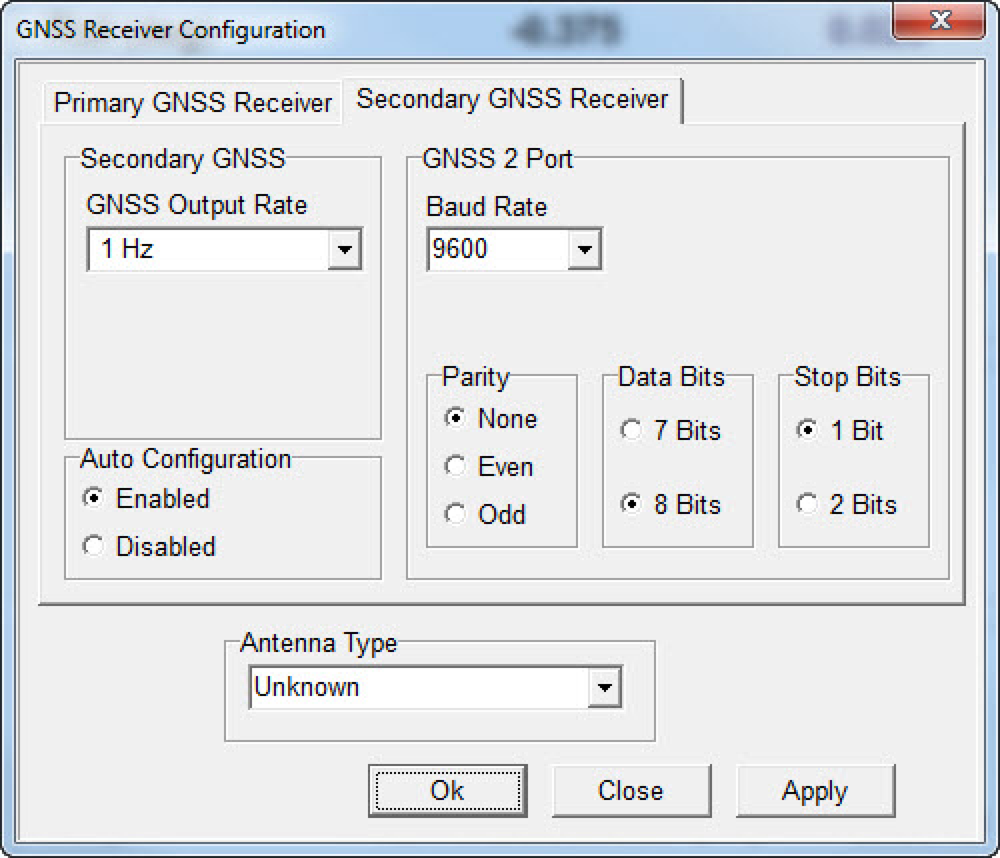

Events
Event 1
Event 2
Event 3
Event 4
Event 5
Event 6
Edge Trigger
Positive
Negative
Guard Time (msec)
1
PPS Out
Polarity
Positive Pulse
Negative Pulse
Pass through
Pulse Width (msec)
1
Ok
Close
Apply

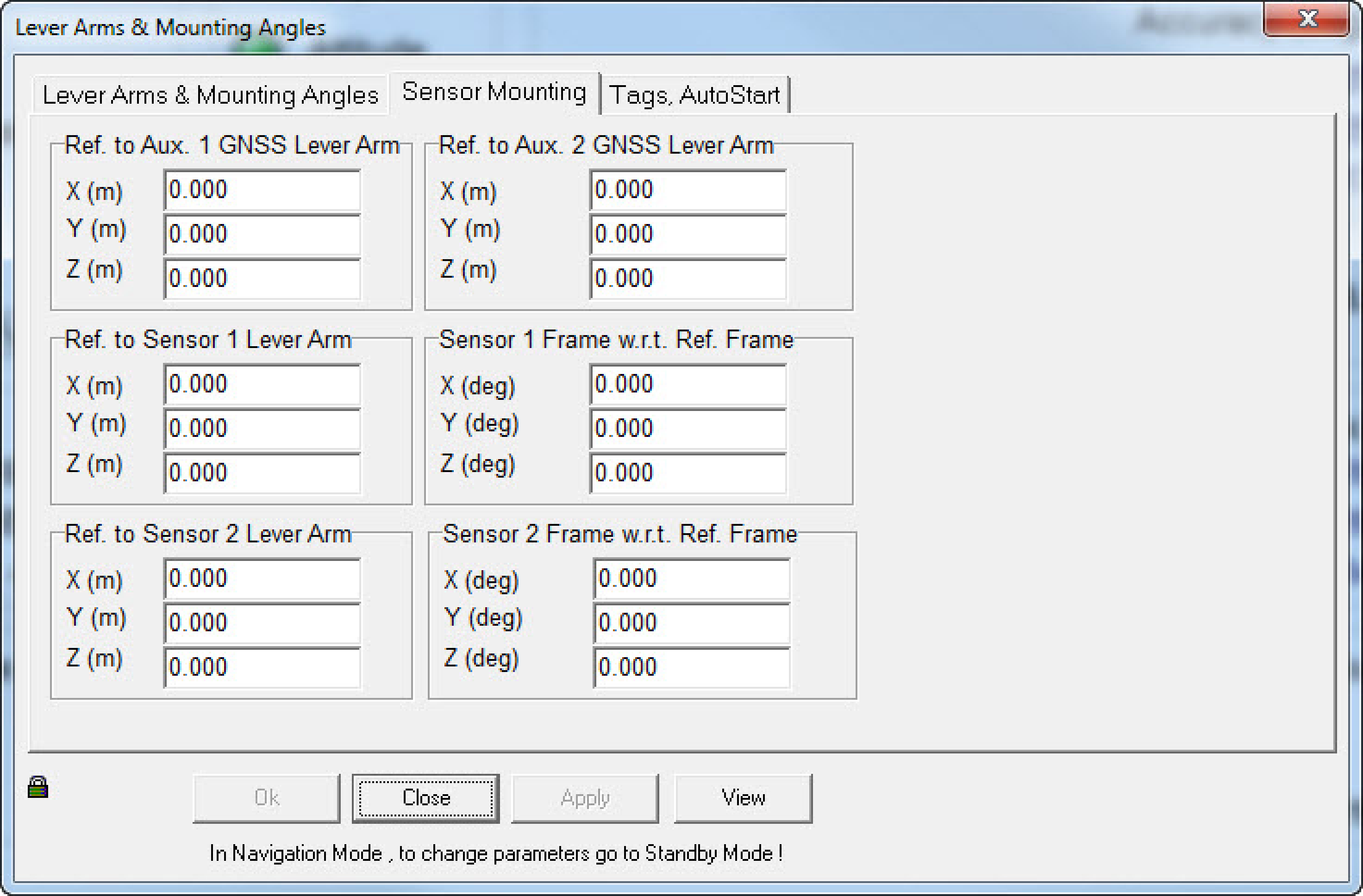

Heave Filter
Heave Bandwidth (sec)
10.000
Damping Ratio
0.707
Ok
Close
Apply

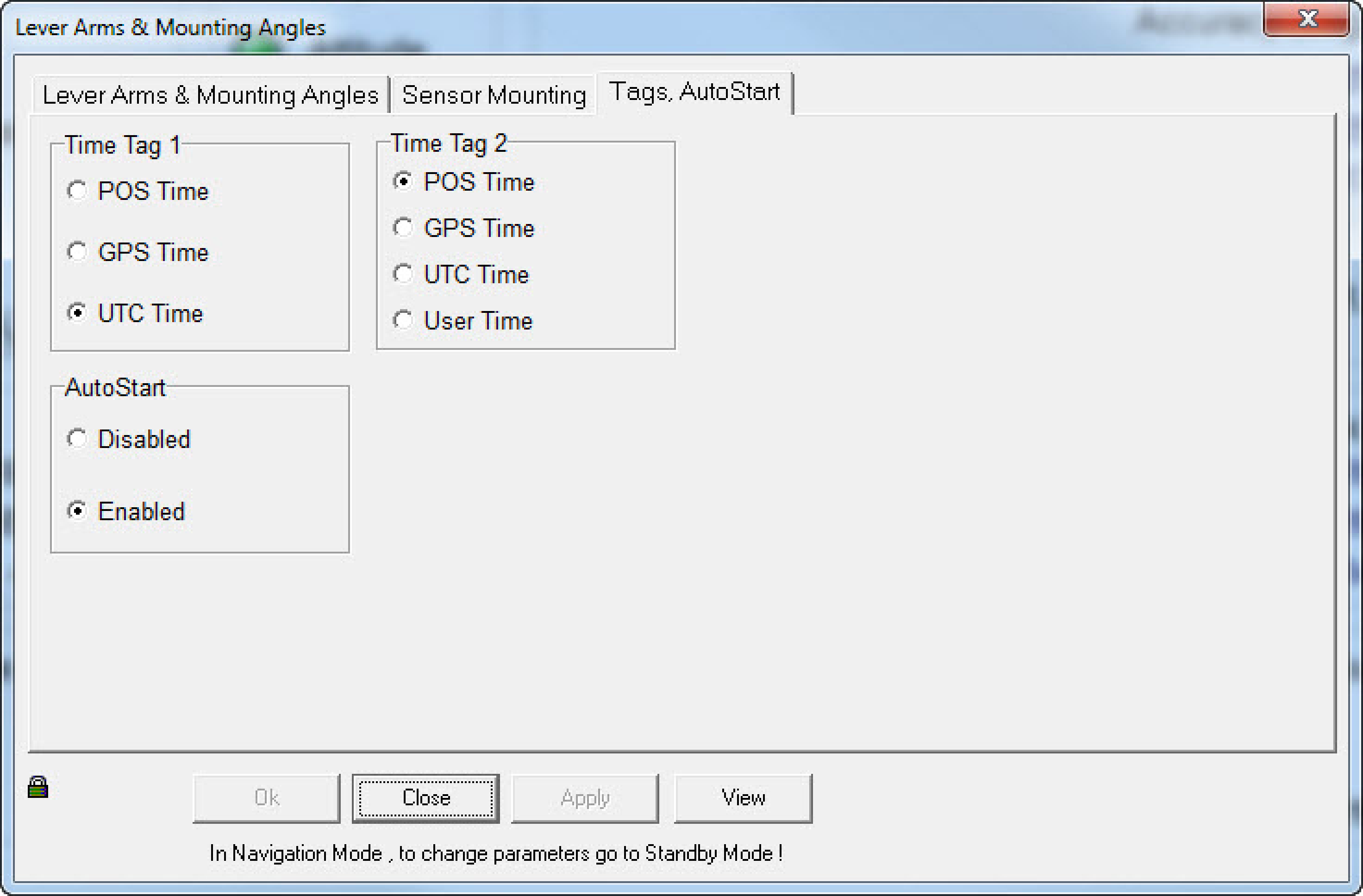

Calibration Control
Lever Arm Calibration Select
Figure of Merit
X (m)
Y (m)
Z (m)
Reference to Primary GNSS
0.000
-9.937
1.389
-22.427
Reference to Auxiliary 1 GNSS
0.000
0
0
0
Reference to Auxiliary 2 GNSS
0.000
0
0
0
Position Fix
0.000
0
0
0
Calibration Action
Last Calibration Action
None
Stop Calibration
Manual Calibration
Auto Calibration
No Action
Normal Transfer
Forced Transfer
Ok
Close
Apply

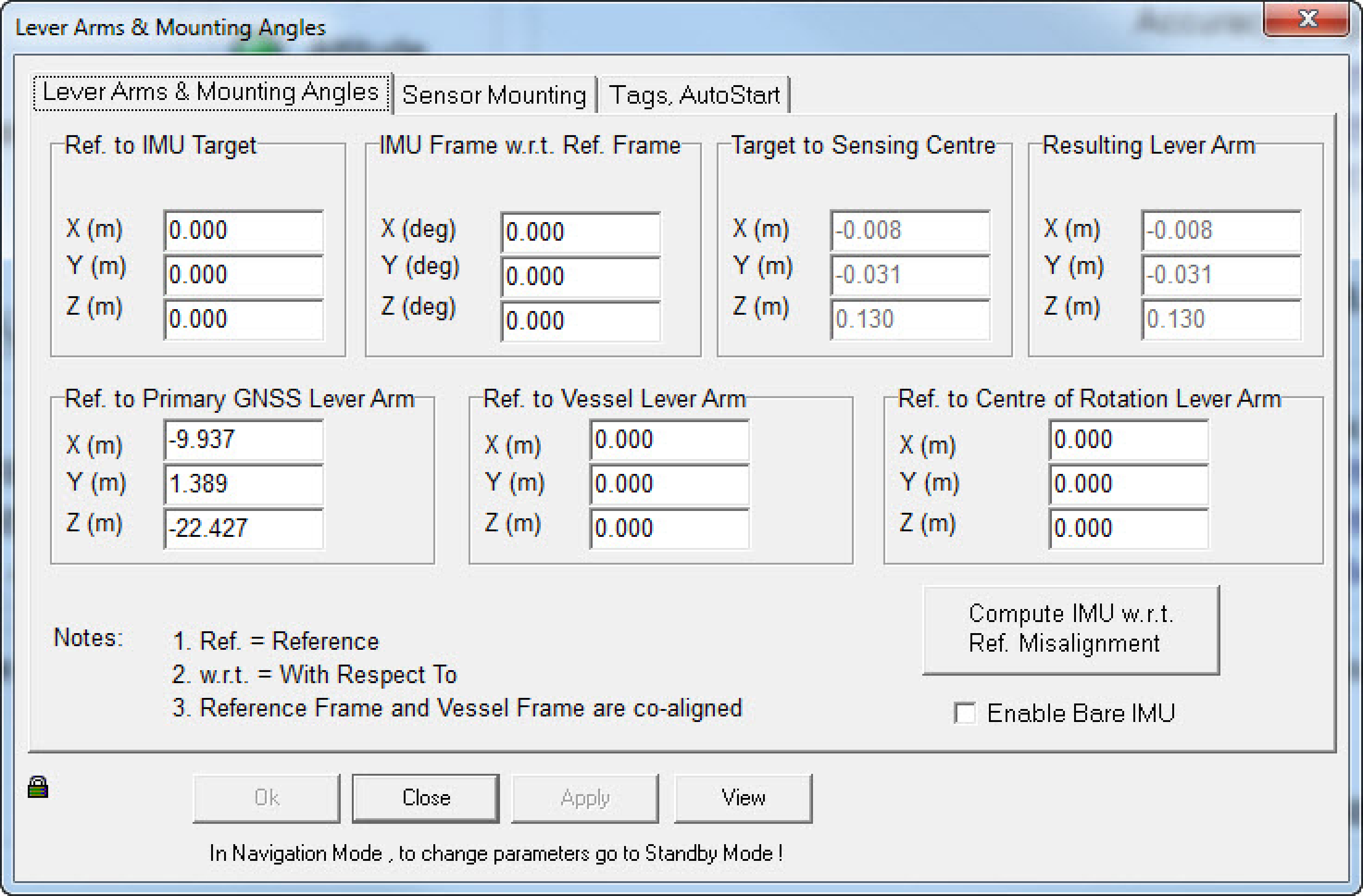

GAMS Parameter Setup
Heading Calibration Threshold (deg)
0.500
Heading Correction (deg)
0.000
Baseline Vector
X Component (m)
0.019
Y Component (m)
2.208
Z Component (m)
-0.009
Ok
Close
Apply
View

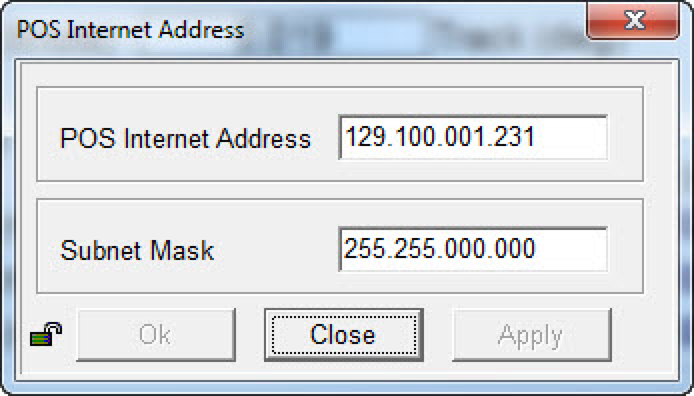

GNSS Receiver Configuration
Primary GNSS Receiver
Secondary GNSS Receiver
Primary GNSS
GNSS Output Rate
1 Hz
GNSS 1 Port
Baud Rate
9600
Parity
None
Even
Odd
Data Bits
7 Bits
8 Bits
Stop Bits
1 Bit
2 Bits
Auto Configuration
Enabled
Disabled
Antenna Type
Unknown
Ok
Close
Apply

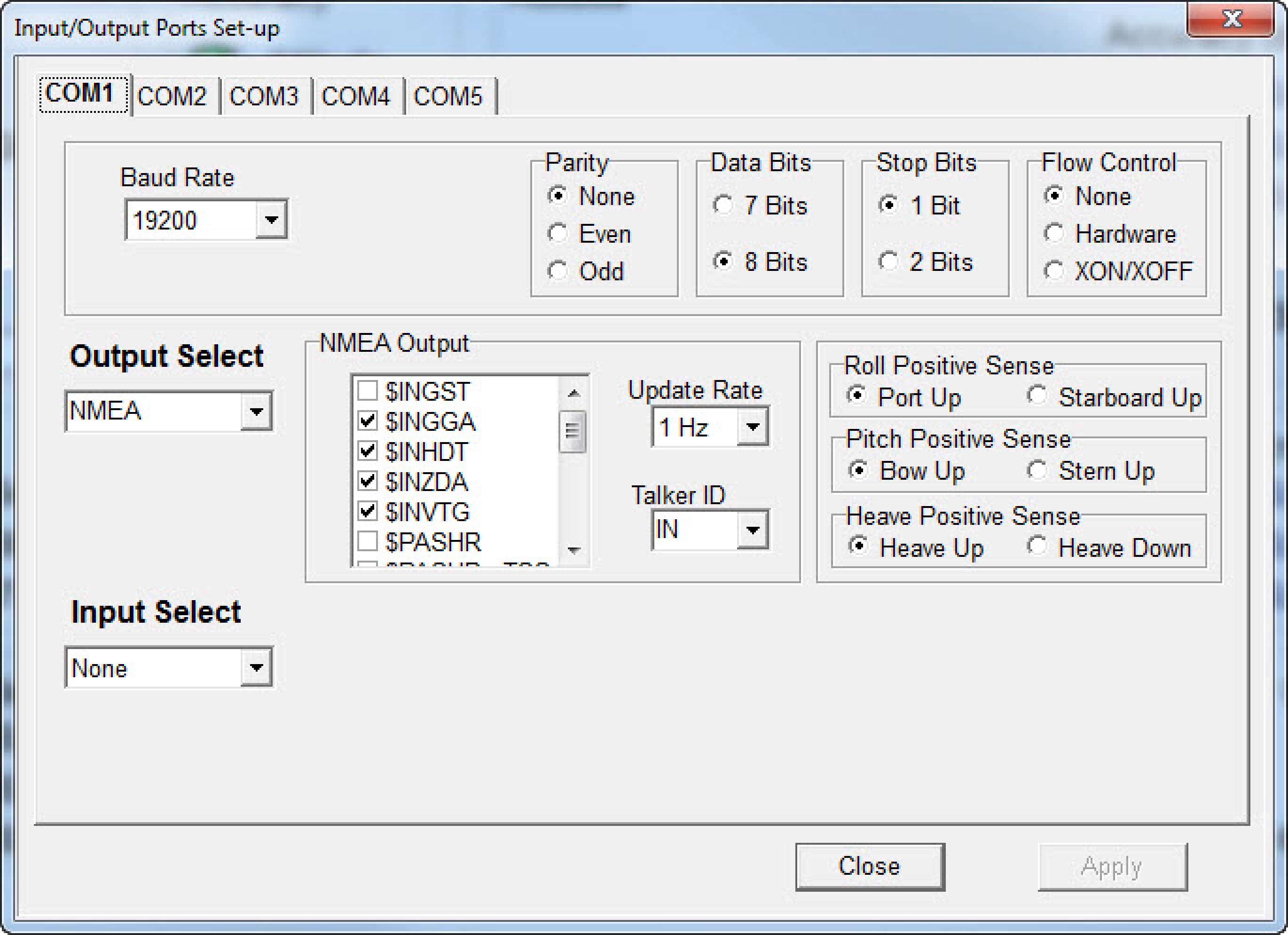

GNSS Receiver Configuration
Primary GNSS Receiver
Secondary GNSS Receiver
Secondary GNSS
GNSS Output Rate
1 Hz
GNSS 2 Port
Baud Rate
9600
Parity
None
Even
Odd
Data Bits
7 Bits
8 Bits
Stop Bits
1 Bit
2 Bits
Auto Configuration
Enabled
Disabled
Antenna Type
Unknown
Ok
Close
Apply

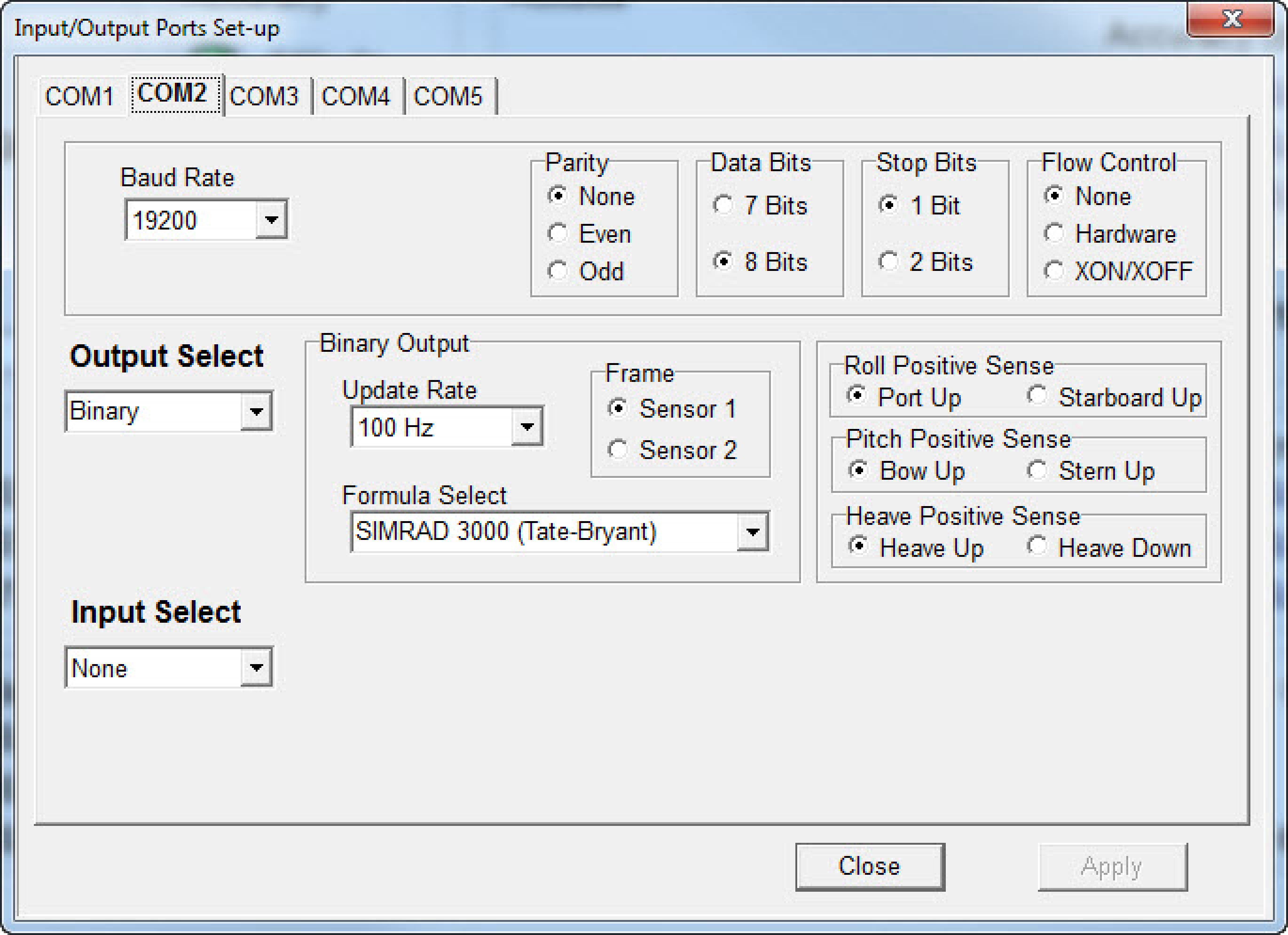

Lever Arms & Mounting Angles
Lever Arms & Mounting Angles
Sensor Mounting
Tags, AutoStart
Ref. to Aux. 1 GNSS Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000
Ref. to Aux. 2 GNSS Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000
Ref. to Sensor 1 Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000
Sensor 1 Frame w.r.t. Ref. Frame
X (deg) 0.000
Y (deg) 0.000
Z (deg) 0.000
Ref. to Sensor 2 Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000
Sensor 2 Frame w.r.t. Ref. Frame
X (deg) 0.000
Y (deg) 0.000
Z (deg) 0.000
Ok
Close
Apply
View
In Navigation Mode , to change parameters go to Standby Mode !

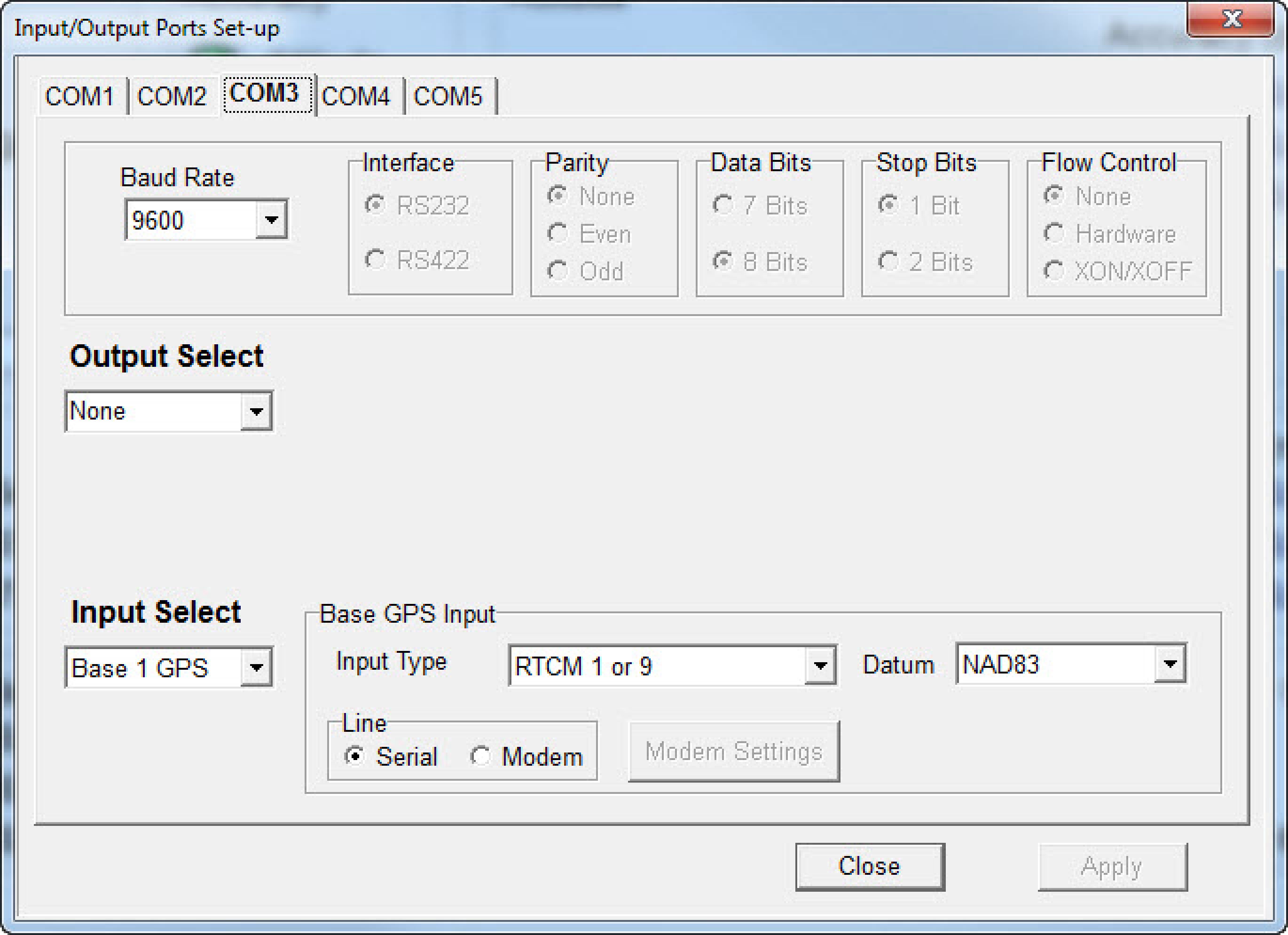

Lever Arms & Mounting Angles
Lever Arms & Mounting Angles
Sensor Mounting
Tags, AutoStart
Time Tag 1
POS Time
GPS Time
UTC Time
Time Tag 2
POS Time
GPS Time
UTC Time
User Time
AutoStart
Disabled
Enabled
Ok
Close
Apply
View
In Navigation Mode , to change parameters go to Standby Mode !

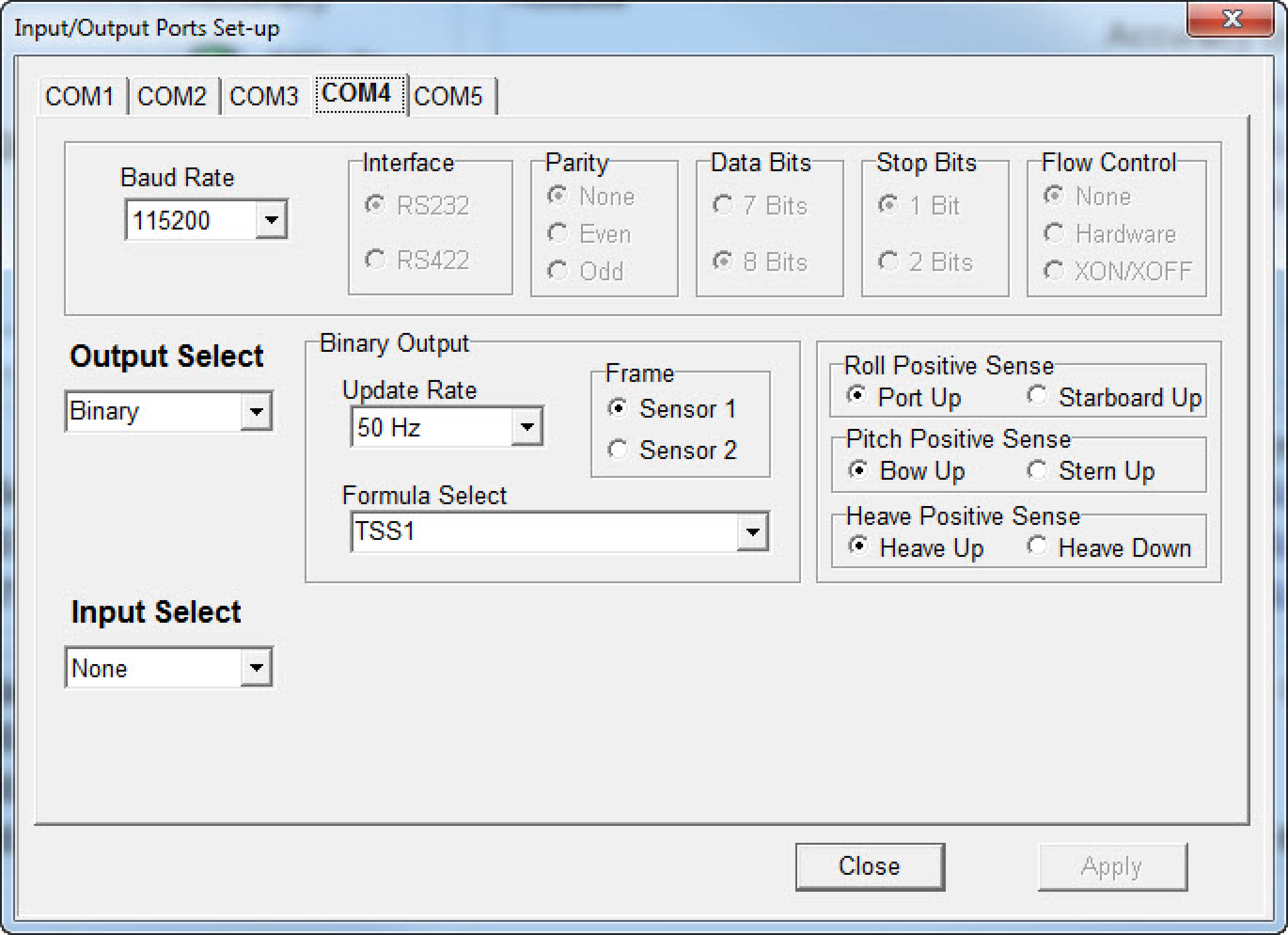

Lever Arms & Mounting Angles
Lever Arms & Mounting Angles
Sensor Mounting
Tags, AutoStart
Ref. to IMU Target
X (m) 0.000
Y (m) 0.000
Z (m) 0.000
IMU Frame w.r.t. Ref. Frame
X (deg) 0.000
Y (deg) 0.000
Z (deg) 0.000
Target to Sensing Centre
X (m) -0.008
Y (m) -0.031
Z (m) 0.130
Resulting Lever Arm
X (m) -0.008
Y (m) -0.031
Z (m) 0.130
Ref. to Primary GNSS Lever Arm
X (m) -9.937
Y (m) 1.389
Z (m) -22.427
Ref. to Vessel Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000
Ref. to Centre of Rotation Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000
Notes:
1. Ref. = Reference
2. w.r.t. = With Respect To
3. Reference Frame and Vessel Frame are co-aligned
Compute IMU w.r.t. Ref. Misalignment
Enable Bare IMU
Ok
Close
Apply
View
In Navigation Mode , to change parameters go to Standby Mode !

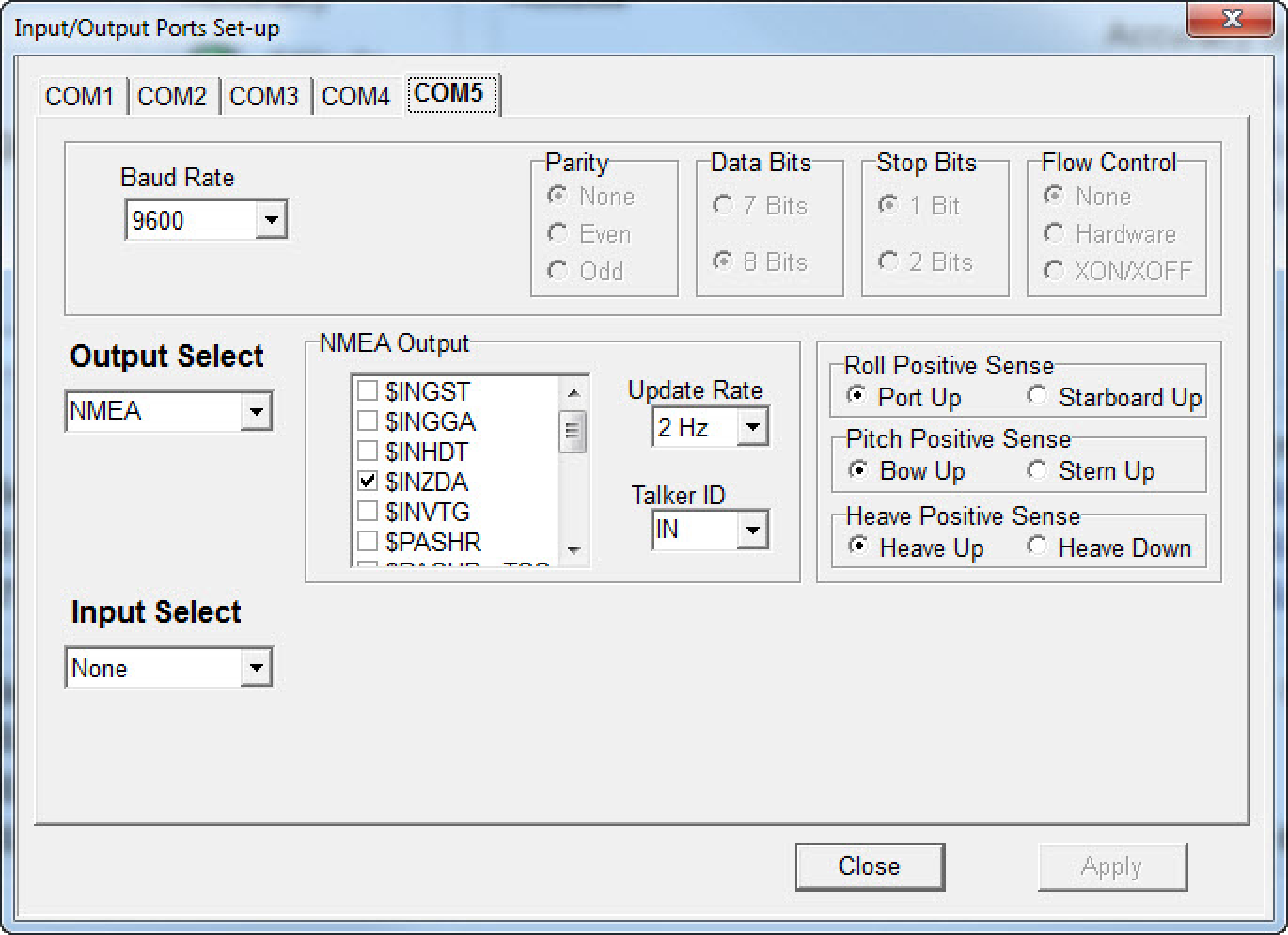

POS Internet Address
POS Internet Address
129.100.001.231
Subnet Mask
255.255.000.000
Ok
Close
Apply

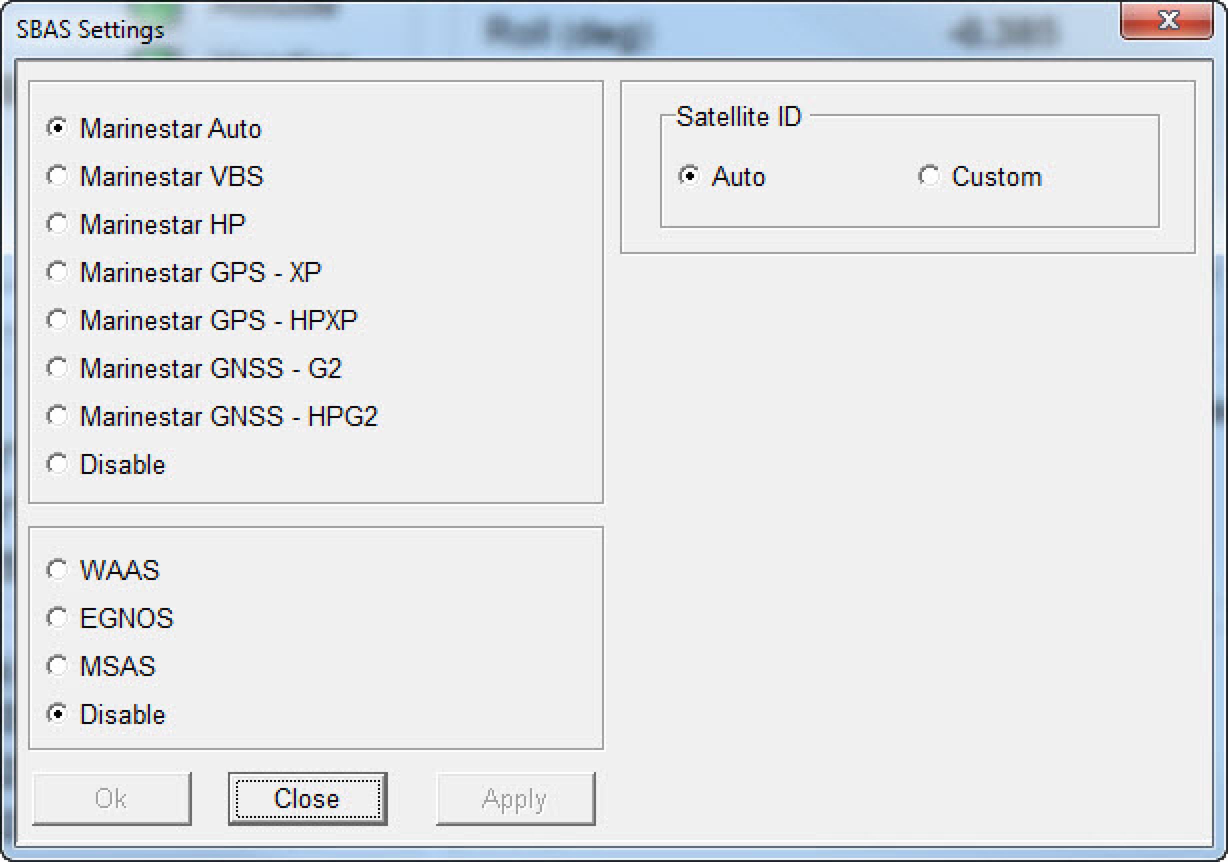

Input/Output Ports Set-up
COM1
COM2
COM3
COM4
COM5
Baud Rate
19200
Parity
None
Even
Odd
Data Bits
7 Bits
8 Bits
Stop Bits
1 Bit
2 Bits
Flow Control
None
Hardware
XON/XOFF
Output Select
NMEA
NMEA Output
$INGST
$INGGA
$INHDT
$INZDA
$INVTG
$PASHR
Update Rate
1 Hz
Talker ID
IN
Roll Positive Sense
Port Up
Starboard Up
Pitch Positive Sense
Bow Up
Stern Up
Heave Positive Sense
Heave Up
Heave Down
Input Select
None
Close
Apply


Input/Output Ports Set-up
COM1
COM2
COM3
COM4
COM5
Baud Rate
19200
Parity
None
Even
Odd
Data Bits
7 Bits
8 Bits
Stop Bits
1 Bit
2 Bits
Flow Control
None
Hardware
XON/XOFF
Output Select
Binary
Binary Output
Update Rate
100 Hz
Frame
Sensor 1
Sensor 2
Formula Select
SIMRAD 3000 (Tate-Bryant)
Roll Positive Sense
Port Up
Starboard Up
Pitch Positive Sense
Bow Up
Stern Up
Heave Positive Sense
Heave Up
Heave Down
Input Select
None
Close
Apply


Input/Output Ports Set-up
COM1
COM2
COM3
COM4
COM5
Baud Rate
9600
Interface
RS232
RS422
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 1 or 9
Datum
NAD83
Line
Serial
Modem
Modem Settings
Close
Apply


Input/Output Ports Set-up
COM1
COM2
COM3
COM4
COM5
Baud Rate
115200
Interface
RS232
RS422
Parity
None
Even
Odd
Data Bits
7 Bits
8 Bits
Stop Bits
1 Bit
2 Bits
Flow Control
None
Hardware
XON/XOFF
Output Select
Binary
Binary Output
Update Rate
50 Hz
Frame
Sensor 1
Sensor 2
Formula Select
TSS1
Roll Positive Sense
Port Up
Starboard Up
Pitch Positive Sense
Bow Up
Stern Up
Heave Positive Sense
Heave Up
Heave Down
Input Select
None
Close
Apply


Input/Output Ports Set-up
COM1
COM2
COM3
COM4
COM5
Baud Rate
9600
Parity
None
Even
Odd
Data Bits
7 Bits
8 Bits
Stop Bits
1 Bit
2 Bits
Flow Control
None
Hardware
XON/XOFF
Output Select
NMEA
NMEA Output
$INGST
$INGGA
$INHDT
$INZDA
$INVTG
$PASHR
Update Rate
2 Hz
Talker ID
IN
Roll Positive Sense
Port Up
Starboard Up
Pitch Positive Sense
Bow Up
Stern Up
Heave Positive Sense
Heave Up
Heave Down
Input Select
None
Close
Apply


SBAS Settings
Marinestar Auto
Marinestar VBS
Marinestar HP
Marinestar GPS - XP
Marinestar GPS - HPXP
Marinestar GNSS - G2
Marinestar GNSS - HPG2
Disable
WAAS
EGNOS
MSAS
Disable
Satellite ID
Auto
Custom
Ok
Close
Apply

Statistics

POS Version

MV-320,VER5,S/N6497,HW1.2-10,SW07.92-Apr08/14,ICD07.15,OS6.4.1,IMU2,PGPS17,SGPS17,RTK-0,THV-0,DPW-0

GNSS Receivers

Primary Receiver

BD982 SN:5409C86558, v.00486, channels:388, OMNSN:1010101793

Secondary Receiver

Options

20,VER5,S/N6497,HW1.2-10,SW07.92-Apr08/14,ICD07.15,OS6.4.1,IMU2,PGPS17,SGPS17,RTK-0,THV-0,DPW-0

Statistics

Total Hours	**16159.4**
Total Runs	**134**
Average Run (hours)	**120.6**
Longest Run (hours)	**1619.9**
Current Run (hours)	**167.8**

Close

Lead Line & Sounding Pole Calibration Report

Field Unit: *NOAA Ship Thomas Jefferson*

(Unique Identifier, with equipment type, date made, etc.) TJSP1

Date of Calibration: March 03, 2017

Method of Calibration: **X Steel tape** ☐ **Permanent graduation marks**
Other

MOC-A Warehouse

Chief of Party: CMD Chris van Westendorp

Lead Line / Sounding Pole Unit of Measure: Meters (This should always be meters!)

Measured by: Glomb	**Recorded by:** Stone	**Checked by: Glomb**
Graduated Marking (a)	**Calibration Measurement (b)**	**Lead Line Corrector (c = b - a)**
1	1.004	0.004
2	2	0
3	3	0
4	3.986	-0.014

Lead Line & Sounding Pole Calibration Report

Field Unit: *NOAA Ship Thomas Jefferson*

(Unique Identifier, with equipment type, date made, etc.) TJSP2

Date of Calibration: March 04, 2017

Method of Calibration: X Steel tape ☐ Permanent graduation marks Other

MOC-A Warehouse

Chief of Party: CDR van Westendorp

Lead Line / Sounding Pole Unit of Measure: Meters (This should always be meters!)

Measured by: Stone	**Recorded by:** Glomb	**Checked by: Stone**
Graduated Marking (a)	**Calibration Measurement (b)**	**Lead Line Corrector (c = b - a)**
1	1.005	0.005
2	2.003	0.003
3	3	0
4	4	0

Lead Line & Sounding Pole Calibration Report

Field Unit: *NOAA Ship Thomas Jefferson*

(Unique Identifier, with equipment type, date made, etc.) **S222 24m**

Date of Calibration: 03/03/2017

Method of Calibration: **X Steel tape** ☐ **Permanent graduation marks**
Other

Chief of Party: CDR van Westendorp

Lead Line / Sounding Pole Unit of Measure: Meters (This should always be meters!)

Measured by: Stone/glomb	**Recorded by:** Stone/glomb	**Checked by: Stone/glomb**
Graduated Marking (a)	**Calibration Measurement (b)**	**Lead Line Corrector (c = b - a)**
1	1	0
2	2.003	0.003
3	3.001	0.001
4	3.998	-0.002
5	4.996	-0.004
6	5.995	-0.005
7	6.995	-0.005
8	7.995	-0.005
9	8.998	-0.002
10	9.995	-0.005
11	10.992	-0.008
12	11.995	-0.005
13	12.999	-0.001
14	13.995	-0.005

Lead Line & Sounding Pole Calibration Report

Field Unit: *NOAA Ship Thomas Jefferson*

(Unique Identifier, with equipment type, date made, etc.) TJ032912_14m

Date of Calibration: 3/3/2017

Method of Calibration: **X Steel tape** ☐ **Permanent graduation marks**
Other

Chief of Party: CDR van Westendorp

Lead Line / Sounding Pole Unit of Measure: Meters (This should always be meters!)

Measured by: Stone/Glomb	**Recorded by:** Stone/Glomb	**Checked by: Stone/Glomb**
Graduated Marking (a)	**Calibration Measurement (b)**	**Lead Line Corrector (c = b - a)**
1	0.998	-0.002
2	1.992	-0.008
3	2.997	-0.003
4	3.991	-0.009
5	4.992	-0.008
6	5.999	-0.001
7	6.998	-0.002
8	7.995	-0.005
9	8.996	-0.004
10	9.994	-0.006
11	10.993	-0.007
12	11.999	-0.001
13	12.992	-0.008
14	13.985	-0.015

Lead Line & Sounding Pole Calibration Report

Field Unit: *NOAA Ship Thomas Jefferson*

(Unique Identifier, with equipment type, date made, etc.) TJ072012_14m

Date of Calibration: 3/3/2017

Method of Calibration: **X Steel tape** ☐ **Permanent graduation marks**
Other

Chief of Party: CDR van Westendorp

Lead Line / Sounding Pole Unit of Measure: Meters (This should always be meters!)

Measured by: Stone/ Glomb	**Recorded by:** Stone	**Checked by: Stone/Glomb**
Graduated Marking (a)	**Calibration Measurement (b)**	**Lead Line Corrector (c = b - a)**
1	0.995	-0.005
2	1.988	-0.012
3	2.992	-0.008
4	3.993	-0.007
5	4.996	-0.004
6	5.985	-0.015
7	6.996	-0.004
8	7.992	-0.008
9	8.998	-0.002
10	9.992	-0.008
11	10.991	-0.009
12	11.993	-0.007
13	12.995	-0.005
14	13.997	-0.003