E/V Nautilus


Engineering Shakedown

Report prepared by: Paul Johnson, Lindsay Gee, Erin Heffron

Photo Credit: Ocean Exploration Trust
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<td>Scott Stamps</td>
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<td>Denise Armstrong</td>
<td>Guest</td>
<td>OET</td>
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<td>Alan Armstrong</td>
<td>Guest</td>
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</table>
NA093 Executive Summary

• Heading into the 2018 operating season, the EM302 and associated sensors aboard the E/V Nautilus are working well compared to the 2017 Quality Assurance Test (QAT) and earlier shipboard assessments.

• The EM302 was calibrated for residual angular offsets using the Seapath 330+ as the primary positioning/attitude system. The patch test revealed that only very slight roll and heading adjustments were required. These biases were entered into the SIS installation parameters for Attitude 1 motion sensor, and should remain unchanged unless modifications are made to the system or there is evidence that another ‘patch test’ is necessary.

• Swath accuracy assessments were conducted over existing shallow and deep reference surfaces that had been collected during the NA079 QAT. Seven different operational settings were run (4 on the deep surface and 3 on the shallow) and analyzed. Results indicate expected and acceptable performance when comparing the data to previously collected accuracy assessments and to other system which have been evaluated. There were some issues with proper sound speed correction for the reference surfaces which did bias the results for the outer portions of the swath. Further work will be done on the crosslines to see if synthetic sound speed profiles applied to the data can better quantify the accuracy of the system.

• NA093 was able to collect deeper data for swath performance analysis (extinction) than was able to be done during NA079. The NA079 testing had revealed that the EM302’s swath width as a function of depth was not performing at the level it had been historically been able to. This issue was eventually identified to be due to marine growth on the hull and array faces causing flow noise. After cleaning the surfaces, data collected during a long deep transit showed that the EM302 was able to match the historic swath performance.
NA093 Executive Summary

- NA093’s extinction data showed that the EM302 was performing better than it had during NA079, but due to the lack of a large sample size for the deeper portion of the extinction test, it is unclear if the EM302 is performing as well as it did during the NA089 transit. If more data is collected during the 2018 field season, please transfer the data to Johnson for analysis.

- Noise testing using the Built-In Self Test in SIS initially seemed to reveal a large ship self-noise problem. However, after consulting with the bridge it was revealed that a doppler speed log was running during the tests. Subsequent testing revealed that noise levels were significantly lower (~48 dB) than those seen during NA079 (~50-54 dB). However, the levels were not as low (~40 dB) as those seen during the initial shipboard acceptance testing done in 2013.

- The heading/sea state related noise testing showed that there was significant difference in the ship’s self noise between heading going into the seas and headings with the seas. When the heading was directly into the seas or there were seas on the port bow, the self-noise of the ship was ~55 dB. When travelling with the seas or waves on the starboard bow, the ships self-noise was ~48 dB.

- From a strictly qualitative assessment the bathymetric data appeared very clean with few flyers and excellent bottom tracking. This was especially apparent at the patch test site where the pitch and yaw lines on the slopes were much easier to work with than the data collected on the same lines in 2017.

- Using a known seep, detected during previous E/V Nautilus mapping, a series of lines were setup to pass directly over the seep, and then be offset from the seep by 450 meters, 900 meters, and 1350 meters ranges. The seep was easily detected in the water column data on both the port and starboard side at all ranges.
The determination of geolocation of seeps using Qimera instead of FM midwater showed significantly less variation in position than when using FM midwater. It is recommended that this method be used for future geolocation.

The Sound Speed Manager software (https://www.hydrooffice.org/soundspeed/main) was updated to the latest version and was used during NA093. The new version of the software was successfully tested for importing sound speed profiles from a Hercules ROV dive. Ideally, both temperature and salinity should be included with the ROV CTD profile for future archiving and for absorption calculation.

The Underway CTD (UCTD) was recalibrated during the off season, and after a minor cabling issue during recovery, the system was successfully used to collect data for determination of sound speed profiles.

There were some issues with SIS stability, especially during the early parts of NA093. This was likely due to heat related issues (the cooling system was disabled after power blackout). Temperature in the sonar room should be carefully monitored.

As has been historically the case, TX board 4 in the TRU caused downtime during data collection and needed to be reseated and power cycled to continue collecting data.

A long time action list item was finally completed at the conclusion of NA093 when the SIS survey list of prior cruise was finally cleaned out. This amounted to removing over 100 surveys, which done over the last 4 years, from the database.

The surface sound speed pump was changed out for a spare due to a worn bearing. No noise issues were detected using the Rxnoise BIST following the change of the unit.
NA093 Executive Summary

• WAAS was forced enabled in the Seapath control software as the automatic SBAS was not functioning.
• During NA093 there was a temperature gradient error with the Seapath which had not been seen before. The error was acknowledges and no further issues were noticed.
• The Seapath Control software was unable to export the Seapath configuration files for backup. This issue should be followed up with Kongsberg to see how it can be resolved.
• Please contact Paul Johnson, pjjohnson@ccom.unh.edu, if there are any questions on any of these matters or any other future questions.
Introduction

The E/V Nautilus undertook a multibeam echosounder quality assurance test from May 30 to June 3, 2018 during an engineering shakedown leg (NA093) in order to perform an assessment of the vessel’s Kongsberg EM302 multibeam echosounder.

Data were collected near the Southern Channel Islands (figure to right), offshore from San Pedro, California. Paul Johnson, Lindsay Gee, and Erin Heffron provided logistical and technical support for mission planning, data collection, and analysis.

This report presents:

• an overview of the data collected and the processing methods applied to it

• a history of all changes made to the system configuration, starting from the initial install and up through the most recent path test calibration

• an accuracy assessments at two depth ranges and swath coverage analysis across all depths surveyed

• amplitudes of vessel self-noise measured by the multibeam receiver at various speeds and headings relative to a prevailing swell

• EM302 impedance data to document receiver and transducer health

• a seep detection assessment trial
Onboard Activities

2018-05-29 (Tues)  Board Nautilus at Alta Sea

2018-05-30 (Wed)  Install updated Sound Speed Manager
                   Documented existing SIS installation parameters
                   Transit to Patch Test Site
                   Underway CTD test
                   XBT procedure test
                   **EM302 calibration (patch test) and verification**

2018-05-31 (Thur)  **EM302 Ship Speed Noise Assessment**
                   **EM302 deep accuracy crosslines** (NA079 reference site)

* Bold font indicates primary EM302 quality assessment tasks. 
### Onboard Activities

<table>
<thead>
<tr>
<th>Date</th>
<th>Activity Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2018-05-31</strong> (Thur)</td>
<td>USBL calibration</td>
</tr>
<tr>
<td></td>
<td><strong>EM302 shallow water crosslines</strong> <em>(NA079 shallow water reference site)</em></td>
</tr>
<tr>
<td><strong>2018-06-01</strong> (Fri)</td>
<td><strong>EM302 seep detection test</strong></td>
</tr>
<tr>
<td></td>
<td>USBL calibration validation</td>
</tr>
<tr>
<td></td>
<td><strong>EM302 deep extinction line</strong></td>
</tr>
<tr>
<td><strong>2018-06-02</strong> (Sat)</td>
<td>Argus test dive</td>
</tr>
<tr>
<td></td>
<td><strong>EM302 deep extinction line</strong></td>
</tr>
<tr>
<td><strong>2018-06-03</strong> (Sun)</td>
<td>USBL calibration validation</td>
</tr>
</tbody>
</table>

*Bold font indicates primary EM302 quality assessment tasks.*
Onboard Activities

2018-06-03 (Sun)  USBL beacon recovery
                    Hercules test dive
                    **EM302 extinction tests during transit to Alta Sea**
                    Docked at Alta Sea complex

2018-06-04 (Mon)  Report writing


* Bold font indicates primary EM302 quality assessment tasks.
The mapping system consists of the following primary components:

1. Kongsberg Maritime EM302 multibeam echosounder (30 kHz), v1.3.1, s/n 110
2. Kongsberg Maritime Seafloor Information System (SIS), v4.3.2
3. Kongsberg Seatex Seapath 330+ vessel navigation system
   I. Seapath 330+ GNSS antennae
   II. MRU 5+, s/n C126NS2018
4. AML Oceanographic Micro-X surface sound speed sensor
5. Sippican MK21 expendable bathythermograph (XBT) profiling system
6. Teledyne Oceanscience UnderwayCTD with Seabird Electronics CTD Profiler
The term ‘system geometry’ means the linear and angular offsets of the primary components of the multibeam mapping system, including the transmit array (TX), receive array (RX), and ship navigation sensor (MRU).

<table>
<thead>
<tr>
<th>Date</th>
<th>Cruise ID</th>
<th>Location</th>
<th>Event</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013 March</td>
<td></td>
<td>Istanbul, Turkey</td>
<td>Install EM302 MBES, Seatex Seapath 330+ MRU, AML Oceanographic surface sound speed sensor, Sippican XBT profile; establish vessel reference frame and survey sensor offsets</td>
<td>Kongsberg Maritime (KM) Harbor Acceptance Test (HAT) report, Parker Maritime survey report</td>
</tr>
<tr>
<td>2013 April</td>
<td>NA025</td>
<td>Toulon, France</td>
<td>EM302 sea acceptance trials; MRU angular offsets determined by patch test and applied in SIS</td>
<td>UNH/IFREMER Sea Acceptance Trials (SAT) report, Gates Acoustic Services report</td>
</tr>
<tr>
<td>2013 June</td>
<td>NA030</td>
<td>Gulf of Mexico</td>
<td>Original MRU 5+ unit replaced with spare by KM engineer at start of NA030</td>
<td>2014 EM302 Multibeam Echosounder System Review</td>
</tr>
<tr>
<td>2014 May</td>
<td>NA040</td>
<td>Gulf of Mexico</td>
<td>Original MRU 5+ unit reinstalled by KM engineer at start of NA040; EM302 system performance review; residual angular offsets determined by patch test and applied in SIS</td>
<td>2014 EM302 Multibeam Echosounder System Review</td>
</tr>
<tr>
<td>2015 April</td>
<td>NA055</td>
<td>Gulf of Mexico</td>
<td>EM302 system performance review; residual angular offsets determined by patch test and applied in SIS</td>
<td>2015 EM302 Multibeam Echosounder System Review</td>
</tr>
<tr>
<td>2016 April</td>
<td>NA070</td>
<td>Victoria, British Columbia</td>
<td>EM302 system performance review; residual angular offsets determined by patch test and applied in SIS</td>
<td>2016 EM302 Multibeam Echosounder System Review</td>
</tr>
<tr>
<td>2017 May</td>
<td>NA079</td>
<td>San Pedro, California</td>
<td>MRU 5+ reinstalled after factory service; EM302 system performance review; residual angular offsets determined by patch test and applied in SIS</td>
<td>2017 EM302 Multibeam Echosounder System Review</td>
</tr>
<tr>
<td>2018 June</td>
<td>NA093</td>
<td>San Pedro, California</td>
<td>EM302 system performance review; residual angular offsets determined by patch test and applied in SIS</td>
<td>2018 EM302 Multibeam Echosounder System Review (this document)</td>
</tr>
</tbody>
</table>
Vessel Survey

- Vessel survey conducted by Parker Maritime AS in Istanbul, Turkey from March 16-20, 2013
- Survey reviewed by UNH/IFREMER team during Sea Acceptance Trials, April 2013, in Toulon France.

- **Origin** of survey reference (the Coordinate Reference Point, CRP) is at x=0 at centerline, y=0 at AP/ frame 0.

- **Linear offsets** reported in meters
  - +X starboard (does not agree with KM/Seapath convention)
  - +Y forward (does not agree with KM/Seapath convention)
  - +Z up (does not agree with KM/Seapath convention)

- **Angular offsets** reported in decimal degrees
  - +Roll with starboard side down (agrees with KM/Seapath convention)
  - +Pitch with bow down (agrees with KM/Seapath convention)
  - +Heading with bow rotation to stbd and port (does not agree with KM/Seapath convention)
Coordinate Systems

**Parker Convention**

*Source: Parker Report (Document 1306029-13000225)*

X, Y, Z, and heading convention are different

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**Kongsberg Convention**

*Source: Kongsberg EM302 Installation Manual*

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**Seapath Convention**

*Source: Applanix POS MV Installation Manual*

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### 4.3.1 Vessel reference system

The following has to be surveyed:

- All vessels have a defined Cartesian coordinate system that all sensors can be referenced to. In this right hand system, the X-axis is positive forwards, which is parallel to the centre line of the vessel, the Y-axis, positive towards starboard, and the Z-axis, which is positive downward.

- The origin in the vessel reference system is typically frame 0 at keel level or the surveyed origin in a survey report, i.e. where X, Y, and Z are all 0.

- The coordinate reference point (CRP) is defined to be in the intersection between stem, longships center line and keel. In case the keel is not parallel with the base line, the reference for CRP is where the keel crosses the vertical section amidships. The location of CRP vs the origin is configurable, and is typically set based on the survey report.

- The reference plane in this system must be well defined and described. This can be a Best Fit Plane on main deck, or a Best Fit Plane through the draught marks on the hull. This is particularly important on a floating vessel, as it is not possible to project the horizontal plane from land.

- The chosen convention must be made clear to all parties involved, both survey personnel performing the survey and the users of the survey results. Any deviation from the defined coordinate system, shown in the figure Definition of Origin on vessel and positive X, Y and Z axes directions on page 54, should be well described in both text and drawings to avoid common misunderstandings.
Seapath antennas are installed on an antenna beam on top of the control van.

Antenna locations as entered into the Seapath 330+ control software are referenced to an origin at the centerline of the ship (Y=0) at frame 0 at the aft end of the ship.

- **Antenna 1 (aft)**
  - X = 18.317 meters
  - Y = -0.200 meters
  - Z = -16.053 meters

- **Antenna 2 (fwd)**
  - X = 20.818 meters (20.815 in Parker)
  - Y = -0.175 meters (same as Parker)
  - Z = -15.986 meters (-15.994 in Parker)

Note: Antenna 1 lever arms exactly match the Parker survey values. Antenna 2 locations have small differences from the values recorded in the Parker report. This is from having run the Calibration wizard, which will adjust the 2nd antenna location as needed.
Seapath IMU Lever Arms

- Parker surveyed the center of top plate for the IMU
- Parker result were used for the lever arm distances from the origin to the IMU in Seapath configuration (‘MRU Geometry’)

Primary IMU Position Distance From Origin:

- X: 33.657 meters
- Y: -0.067 meters
- Z: -2.628 meters

- The IMU is the reference point in the Kongsberg coordinate system.

Primary IMU Position Kongsberg Reference Frame:

- X: 0.000 m
- Y: 0.000 m
- Z: 0.000 m
Seapath IMU Mounting Angles

- Parker surveyed the center of top plate for the IMU
- Angular offsets from the Parker report were transformed into the Kongsberg convention.

**Primary IMU Angles:**
- Roll: 179.400 degrees
- Pitch: 1.760 degrees
- Yaw: -0.510 degrees
TX & RX Linear Offsets

- Linear offsets from Parker report were transformed into the Kongsberg convention
  - Origin at MRU center of top plate
  - All units in meters
  - +X forward
  - +Y starboard
  - +Z down

- Values entered into the SIS installation parameters Locations panel were verified to match those determined during the system geometry review.

- **EM302 TX Transducer**
  - X: 3.496 m
  - Y: -0.137 m
  - Z: 2.731 m

- **EM302 RX Transducer**
  - X: 1.516 m
  - Y: 0.033 m
  - Z: 2.732 m
System Geometry Review

TX & RX Angular Offsets

- Angular offsets from Parker report were transformed into the Kongsberg convention
  - All units in degrees
  - +Roll starboard side down
  - +Pitch bow up
  - +Heading bow to starboard (compass convention)

- Values entered into the SIS installation parameters Angular Offsets panel were verified to match those determined during the system geometry review.

- **EM302 TX Transducer**
  - Roll: 0.61 degrees
  - Pitch: 0.01 degrees
  - Heading: 0.22 degrees

- **EM302 RX Transducer**
  - Roll: 0.72 degrees
  - Pitch: 0.32 degrees
  - Heading: 0.08 degrees
The waterline value entered in the Installation Parmaters/Locations tab was derived during the 2013 shipboard acceptance test.

By evaluating the pre-departure draft marks at the front of the vessel (figure 1) and rear (figure 2) it was determined that the ship rests slightly bow up by about ~0.8 meters.

Using this information, a waterline adjustment of 0.6 meters was calculated in the ship’s reference plan at the TX array face. This adjustment changed the water line z from -2.372 to -1.77.

It is worth noting that the ship might be resting differently now (figure 3) than it had been in 2013 and the Waterline value could be adjusted accordingly.
EM302 Calibration

Site Selection and Data Collection

1. The calibration site was selected and used during the NA079 2017 QAT based on the availability of seafloor features with optimal slopes and bathymetric relief within the operations area.

2. Lines were run at 8 kts, instead of the usual 6kts due to engine constraint issues, in the order of pitch, roll, and heading.

3. XBTs were collected as needed throughout the calibration process.

4. It should be noted that the EM302 tracked the slopes of the pitch and heading lines far better during NA093 than it had during the NA079 QAT.
Pre-Calibration Configuration

1. All *Attitude 1* angular offsets were left with the offsets determined during the 2017 NA079 QAT in the *SIS Installation Parameters / Angular offsets* panel.

2. Calibration data were examined by Johnson, Gee, and Heffron using patch test tools in both SIS and Qimera; results were agreed upon by multiple personnel.

3. The biases determined during each were were updated in the *SIS Installation Parameters* for *Attitude 1* prior to starting the next test, in order to reduce the effects of coupling.

4. As the offsets were very small, there was no need to run verification lines to test the results.

5. No latency test was performed, as previous testing of the system had not revealed any latency or latency-related artifacts and it is not clear that any very small latency that might exist within the system would be detectable using deep water data.
EM302 Calibration

Results: Roll

- Roll verification lines shown at left in the Qimera Patch Test Tool

1. Pre-NA093 roll offset value: +0.16°
2. NA093 calculated bias: -0.02°
3. Final roll offset: +0.14° entered into the SIS Installation Parameters/Angular Offsets panel.
EM302 Calibration

Results: Pitch

- Pitch verification lines shown at left in the Qimera Patch Test Tool

1. Pre-NA093 pitch offset value: -0.13 °
2. NA093 calculated bias: 0.0 °
3. Final pitch offset: -0.13° entered into the SIS Installation Parameters/Angular Offsets panel.
EM302 Calibration

Results: Heading

• Heading verification lines shown at left in the Qimera Patch Test Tool

1. Pre-NA093 pitch offset value: -0.02°
2. NA093 calculated bias: +0.03°
3. Final heading offset: +0.01° entered into the SIS Installation Parameters/Angular Offsets panel.
EM302 Calibration

Post-Calibration Configuration

1. The small offsets applied to the pitch and roll in the *Attitude 1* angular offsets reflect a stable system geometry with no significant changes in either system geometry or integration.

2. The *Installation Parameters: Angular Offsets*, shown at left, should not be changed, unless a new patch test is undertaken.
1. Accuracy of a multibeam echosounder under ‘normal’ survey conditions can be assessed by examining soundings collected during a single-pass survey lines over a trusted bathymetric surface (a reference surface).

2. Reference surfaces typically cover flat or gently sloping terrain that have been carefully and densely surveyed, providing a large sample count and high degree of confidence in the depth of each grid cell.

3. Accuracy assessments during quality assessment testing provides a baseline to judge system performance against previous years results. This testing can help reveal both potential changes to the system itself, as well as changes to the operation environment.

4. With rigorous testing protocols and consistent analysis methods, accuracy performance data can provides a critical window into performance over the system’s service life and may help to identify early signs of component failure.
5. For a complete evaluation, accuracy data should be collected in all operational modes over reference surfaces in depths appropriate for those modes.

6. ‘Deep’ and ‘Shallow’ operational modes for the EM302 were tested during NA097 cruises using two reference surfaces collected during NA079 QAT in 2017.

7. The two surfaces cover significantly different depth ranges and therefore test different modes of the sonar.

8. By using the NA079 reference surfaces, a significant amount of time was saved by not needing to survey the whole of the surface.
Swath accuracy over ‘deep’ terrain (relative for the 30-kHz EM302) was assessed by running a series of crosslines over a ‘deep’ reference surface in 1250-1350 m depths collected during the 2017 NA079 QAT.

Crosslines were oriented to maximize coverage across reference surface and were orthogonal to the lines used to collect the data contributing to the surface, in order to reduce any potential coupling of EM302 biases across the swath.

Deep accuracy crosslines were run in four settings, starting with the most conventional configuration for the environment (changes from previous settings are shown in red in the table on the next page).

An XBT profile was collected prior to crosslines.

All lines were run at 8 knots, except crossline 3a which was run at 11 knots due to carbon buildup in the stack.
Deep Accuracy: Data Collection

<table>
<thead>
<tr>
<th>Crossline Setting</th>
<th>Ping Mode</th>
<th>Swath Mode</th>
<th>Pulse Form</th>
<th>Yaw Stabilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setting 1</td>
<td>Deep</td>
<td>Dual Swath (Dynamic)</td>
<td>FM Enabled*</td>
<td>RMH**</td>
</tr>
<tr>
<td>Setting 2</td>
<td>Deep</td>
<td>Dual Swath (Dynamic)</td>
<td>CW</td>
<td>RMH**</td>
</tr>
<tr>
<td>Setting 3</td>
<td>Deep</td>
<td>Single Swath</td>
<td>FM Enabled*</td>
<td>RMH**</td>
</tr>
<tr>
<td>Setting 3a</td>
<td>Deep</td>
<td>Single Swath</td>
<td>FM Enabled*</td>
<td>RMH**</td>
</tr>
<tr>
<td>Setting 4</td>
<td>Deep</td>
<td>Dual Swath (Dynamic)</td>
<td>FM Enabled*</td>
<td>Off</td>
</tr>
</tbody>
</table>

* With FM enabled, in this depth range, the EM302 used a ‘MIX’ transmission with CW inner sectors and FM outer sectors. With FM disabled, only CW pulse forms were used for all sectors (e.g., Setting 2).

** RMH = Relative Mean Heading

*** Setting 3a had the same sonar runtimes, but was run at 11 knots instead of 8 knots due to carbon buildup in the stack.
EM302 Accuracy Testing

Deep Accuracy: Analysis Procedure

1. The bathymetric data were corrected for tide using the Oregon State Tidal model.
2. The reference surface was gridded at 40 m (figure 1).
3. Grid cells with <10 soundings in a node were removed from the reference surface (figure 2).
4. Grid cells with slopes >5° were removed from the reference surface (figure 3).
5. The remaining grid cells with ≥10 soundings and slopes ≤5° were used for analysis of the NA093 deep accuracy crossline data (figure 4).
6. Crosslines were very lightly processed to remove extreme outliers, "flyers", from being included in the analysis.
7. The mean depth bias and depth bias standard deviations as a percentage of water depth were then computed in 1° angular bins across the swath for each configuration.
EM302 Accuracy Testing

Deep Accuracy: Results

- The EM302 provides fairly unbiased soundings over the majority of the swath in all of the different modes tested over the deep reference surface.
- A noticeable non-linear refraction bias (frown) is present in the outer portions of the swath for each mode tested.
- The observed trends in standard deviations (right-top plots of the crossline results) are still within the expected performance tolerances of the system and are almost identical to that observed during previous QATs.
- The standard deviations about the mean bias are typically within +/-0.15% to +/-0.25% water depth (1-σ) across the majority of the swath with higher uncertainties at the limits of the swath, as expected and typical for these systems.
- At TX sector boundaries (approx. ±32-35°) with FM enabled, the mean depth bias tends to jump by ~0.05% WD and the depth standard deviation tends to jump by ~0.025% WD.
- The 2018 accuracy assessment shows depth standard deviation trends across the swath that are as good as previous evaluations.

Example of swath accuracy as a percentage of water depth (left) and depth (right) with NOAA thresholds

Results for each setting are presented in the following slides.
EM302 Accuracy Testing

Deep Setting 1 - DUAL/DEEP/MIX/RMH

Red: Mean Depth Bias   Blue: Depth Std. Dev. (top: 2σ ~ 95% CI)

Special Order

Order 1

Order 2
EM302 Accuracy Testing

Deep Setting 3 - SINGLE/DEEP/MIX/RMH

Red: Mean Depth Bias  Blue: Depth Std. Dev.

Red: Mean Depth Bias  Blue: Depth Std. Dev. (top: $2\sigma \sim 95\%$ CI)
EM302 Accuracy Testing

Deep Setting 3a - SINGLE/DEEP/MIX/RMH/11kts

Red: Mean Depth Bias   Blue: Depth Std. Dev.

Red: Mean Depth Bias   Blue: Depth Std. Dev. (top: $2\sigma \sim 95\%$ CI)
EM302 Accuracy Testing

Deep Setting 4 - DUAL/DEEP/MIX/NO YAW


Red: Mean Depth Bias   Blue: Depth Std. Dev.

Red: Mean Depth Bias   Blue: Depth Std. Dev. (top: 2\sigma ~ 95% CI)
EM302 Accuracy Testing

Shallow Accuracy: Testing Procedure

1. Swath accuracy over ‘shallow’ terrain (relative for the 30-kHz EM302) was assessed by running a series of crosslines over a ‘shallow’ reference surface in 100-150 m depths collected during the 2017 NA079 QAT.

2. Crosslines were oriented to maximize coverage across reference surface and were orthogonal to the lines used to collect the data contributing to the surface in order to reduce any potential coupling of EM302 biases across the swath.

3. Shallow accuracy crosslines were run in three settings, starting with the most conventional configuration for the environment (changes from previous settings are red in the table below).

4. An XBT profile was collected prior to crosslines

5. All lines were run at 8 knots

<table>
<thead>
<tr>
<th>Crossline Setting</th>
<th>Ping Mode</th>
<th>Swath Mode</th>
<th>Pulse Form</th>
<th>Yaw Stabilization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Setting 1</strong></td>
<td>Shallow</td>
<td>Dual Swath (Dynamic)</td>
<td>CW</td>
<td>RMH*</td>
</tr>
<tr>
<td><strong>Setting 2</strong></td>
<td>Shallow</td>
<td>Single Swath</td>
<td>CW</td>
<td>RMH*</td>
</tr>
<tr>
<td><strong>Setting 3</strong></td>
<td>Shallow</td>
<td>Dual Swath (Dynamic)</td>
<td>CW</td>
<td>Off</td>
</tr>
</tbody>
</table>

* RMH = Relative Mean Heading
1. Bathymetric data were corrected for tide using the Oregon State Tidal model.

2. The reference surface was gridded at 5 m (figure 1).

3. Grid cells with <10 soundings in a node were removed from the reference surface (figure 2).

4. Grid cells with slopes >5° were removed from the reference surface (figure 3).

5. The remaining grid cells with ≥10 soundings and slopes ≤5° were used for analysis of the NA093 deep accuracy crossline data (figure 4).

6. Crosslines were very lightly processed to remove extreme outliers, "flyers", from being included in the analysis.

7. The mean depth bias and depth bias standard deviations as a percentage of water depth were then computed in 1° angular bins across the swath for each configuration.
The EM302 provides fairly unbiased soundings over the majority of the swath in all of the different modes tested over the shallow reference surface.

A noticeable non-linear refraction bias (smile) is present in the outer portions of the swath for each mode tested.

Within +/-10° the data shows ‘Erik’s Horns`, a nadir-ringing bottom tracking artifact. Which has been seen before when mapping in shallow water.

The observed trends in standard deviations (right-top plots of the crossline results) are still within the expected performance tolerances of the system in this water depth, and are almost identical to that observed during previous QATs.

The standard deviations about the mean bias are typically within +/-0.2% to +/-0.3% water depth (1-σ) across the majority of the swath with higher uncertainties at the limits of the swath, as expected and typical for these systems.

As has been noted before, running the system with dual swath off yields data with higher accuracy when compared to the two passes with dual swath enabled.

The 2018 accuracy assessment shows depth standard deviation trends across the swath in shallow depths that are as good as previous evaluations.
EM302 Accuracy Testing

Shallow Setting 1 - DUAL/SHALLOW/CW/RMH

Red: Mean Depth Bias   Blue: Depth Std. Dev.
EM302 Accuracy Testing

Shallow Setting 2 - SINGLE/SHALLOW/CW/RMH

Red: Mean Depth Bias   Blue: Depth Std. Dev.

E/V Nautilus – EM302 – Xline 2 – Single/CW
EM302 Accuracy Testing

Shallow Setting 3 - DUAL/SHALLOW/CW/NO YAW

E/V Nautilus – EM302 – Xline 3 – Shallow/Dynamic/CW/NoYaw

Red: Mean Depth Bias   Blue: Depth Std. Dev.

E/V Nautilus – EM302 – Xline 3 – Shallow/Dynamic/CW/NoYaw

Red: Mean Depth Bias   Blue: Depth Std. Dev.
XBT, CTD, and UCTD Comparison

• As in prior years, a goal of the QAT was to assess the quality of the sound velocity profiles derived from:
  • Teledyne Oceanscience Underway CTD - calibrated March 2018
  • Sippican MK21 XBT
  • Seabird SBE49 FastCAT CTD mounted on ROV Hercules

• It had been intended to undertake near simultaneous UCTD and XBT observations, but problems recovering the UCTD delayed the XBT by about two hours.

• The HydrOffice Sound Velocity Manager (https://www.hydroffice.org/soundspeed/main) was modified prior to NA093 to support the SVP format generated during a ROV Hercules ascent.

• This functionality was tested on a dive in the same location a few days after the initial XBT and UCTD observations. It is intended to use this profile when mapping is started after a dive instead of deploying a UCTD or XBT.

• The figure to the left shows the results of the SVP and UCTD and XBT data, as well as a profile from Hercules.

• The profiles derived from the XBT and UCTD data are consistent in shape but divert in some of the mid-range. This is likely be from uncertainty in the drop rate of the XBT which is used to calculate the depth, unlike the UCTD which is calculated from a pressure sensor. The shape of the Hercules profile is generally consistent but no further assessment can be made noting the separation of observations.
EM302 Swath Coverage

Overview

- During all transits for NA093, the EM302 was run in automatic ping mode with swath angle limits of ±75° to let the system automatically select its preferred depth mode and attempt to maximize swath coverage.

- Distance from nadir was then calculated for the outermost port and starboard soundings for each ping and then plotted against depth to evaluate trends in the achieved swath width versus depth.

- Soundings that appeared to be outliers, relative to the surrounding bathymetry, were removed from analysis; likewise, soundings that had abnormally high or low backscatter strengths (characteristic of slopes facing toward or away from the EM302) were also ignored during analysis.

- The results provide a baseline swath coverage curve in depths of approximately 80-3750 m; this curve is useful for survey planning and comparison to future swath coverage data.

* Note that transits were mostly conducted at 10 kts rather than a typical extinction speed of 6-8 kts and were not always run orthogonal to seafloor structure as preferred.
EM302 Swath Coverage

Results

• The plot to the left shows the swath coverage (extinction) in rainbow colors for the EM302 over the range of 80m to 3750 meters water depth.

• The underlying grey points document the historic swath performance of the system from data collected during 2015 and 2016 QATs, as well as data from collected during the 2017 field season.

• The 2017 QAT had identified a potential ship self-noise issue which seemed to be affecting the EM302’s ability to maximize its swath potential (see next page). Because of this, careful attention was paid this year to look at the noise of the ship (see later section), as well as to examine the swath performance (this section).

• While the system is performing better than 2017 QAT, it does not appear to be doing quite as well as it had been historically (grey dots in figure), especially when comparing it to the NA089 transit, which was collected following the cleaning of the array face.

• However, this might be due to the lack of data in the deeper ranges of the plot and from surveying over different bottom types. If any further data is which is suitable for extinction analysis, please submit it to Paul Johnson for further analysis.
**EM302 Swath Coverage**

Full depth range (0-3750 meters) swath coverage plot for NA093

Shallow depth range (0-500 meters) swath coverage plot for NA093.

**Results**
The above two plots document the swath width over the same depth range. The left plot shows the 2018 data collected during NA093 and the right plot shows the NA079 data collected in 2017. The 2017 report noted that the swath width was already reduced to \(~3.5 \times \text{water depth}\) at 1750 meters. The 2018 data shows that the swath width is \(~4 \times \text{water depth}\) at 1750 meters. This is likely due to the decrease in the self-noise of the ship from marine growth removal which happen post NA079.
A full Built-In Self-Test (BIST) diagnostic routine was run prior to departure as well as a few times while underway.

BISTs provide the ability to perform impedance measurements of the transmitter and receiver arrays and receiver.

These types of test results may be used as proxies for the health of array transducer elements and receivers.

Routine RX and TX Channel BISTs may aid early detection of element degradation. This is an important condition to monitor, as these arrays have been known to degrade with time.

It is important to note that the BIST impedance measurements do not provide a full characterization of transducer properties as a function of frequency.
EM302 Transducer Health

**Impedance – Receiver**

- EM302 receiver impedance levels collected by BIST tests from 2013 to 2018.
- This plot includes all BISTs which have been collected and stored on the EM302 acquisition machine, regardless of the reason they were collected.
- Y-Range for impedance is based on the acceptable range defined to pass a BIST test as defined by Kongsberg.
- Current receiver impedance values show relatively uniform levels across all channels and confirm no open or short-circuit conditions at the start of the system’s service life.
- There has been very little change in amplitude or variation in pattern over the 6 year period of testing.
EM302 Transducer Health

**Impedance – Receiver Transducer**

- EM302 receiver transducer impedance levels collected by BIST tests from 2013 to 2018.
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- Current receiver transducer impedance values show relatively uniform levels across all channels and confirm no open or short-circuit conditions at the start of the system’s service life.
- There has been very little change in amplitude or variation in pattern over the 6 year period of testing.
EM302 Transducer Health

Impedance - TX Channels

- TX impedance looks remarkably like that observed during 2017 (see figure below).
- All but one transmitter array element impedance value fell within the expected normal ranges.
- Channel 15 in TX slot 12 still reports a high impedance value. However, this single element was noted starting in 2014 as exceeding the expected range, and no change has been observed since.
Overview

- A potentially major limitation of multibeam performance can stem from elevated noise levels due to hull design, engine and other machinery, sea state, biofouling, electrical interference, etc.

- The QAT included a series of tests to identify contributions to the noise environment perceived by the EM302 receiver array due to vessel speed, and vessel heading relative to the prevailing swell.

- These tests were run using a script which will conduct and record 10 individual EM302 Built-In Self-Test (BIST) routines for RX Noise under each different speeds and heading of interest, in order to characterize the vessel’s platform noise environment.

- After a round of initial testing when a Doppler speed log was running, all further tests were run after it was confirmed that all other acoustic systems on the ship were secured.
EM302 Noise Level Assessment

Speed Tests – With Seas

E/V Nautilus EM302 Self Noise vs Speed - With Seas

Speed (kts)
10 8

RX Module
112 96 64 48 32 16 0

Self Noise (dB re 1μPa/√Hz)
30 35 40 45 50 55 60 65 70

Test #
10 20 30 40 50

Median
Mean (log)
Mean (lin.)

Speed (kts)
7 8 9 10 11

Self Noise (dB re 1μPa/√Hz)
30 35 40 45 50 55 60 65 70
EM302 Noise Level Assessment

Speed Tests - Results

- Noise testing was only able to be completed from 7 to 11 knots speed due to engine issues.
- The elevated noise levels (~50-54 dB) observed during the 2017 QT were observed to be significantly reduced in 2018 (~48 dB).
- 2017 issues were shown to be a fouled array faces (picture below).
- Following cleaning noise was lowered dramatically.
- 2018 noise levels (~48 dB) are still higher than those observed during the 2013 SAT (~40 dB).
- The surface sound speed pump was changed during NA093, but no change was observed in the associated self-noise of the ship.
EM302 Noise Level Assessment

E/V Nautilus EM302 Self Noise vs Azimuth - Octagon

Self Noise (dB re 1μPa/√Hz)

Test #

RX Module

Azimuth (deg)

0 45 90 135 180 225 270 315 360

10 20 30 40 50 60 70 80 90

dB
EM302 Noise Level Assessment

E/V Nautilus EM302 Self Noise vs Azimuth - Octagon

- Median
- Mean (log.)
- Mean (lin.)

- IntoSeas
- WithSeas

Azimuth (deg)

Self Noise (dB re 1μPa/√Hz)

40 45 50 55 60 65 70

Port 0 45 90 135 180 225 270 315 360 Stbd

IntoSeas

WithSeas

Input by ADVISE
EM302 Noise Level Assessment

Heading Test - Results

- Environmental Conditions:
  - Swell: 1.5 – 2 meters
  - Winds: 10 kts
  - Wind Direction: 315 degrees
  - Ship Speed: 8 knots

- Heading has been adjusted so that 0 degrees is into seas.

- The plot to the left shows that travel into the seas (waves on the bow) and waves impacting on the port bow caused the greatest increase in noise (~55 db). Seas on the aft end and starboard quarter are significantly quieter (~48 db).

- This is a very similar results as seen in other years when there has been enough sea state to conduct a heading (octagon test).
Similar to the 2017 QAT, during the NA093 we once again tested the seep detection capabilities of the E/V Nautilu’s EM 302 on a known seep in San Pedro basin.

The test was conducted where the local seafloor depth of the seep were ~900m. Over the seep a series passes were run initially directly over the seep, followed by lines 450 meters out, 900 meters out, and then 1350 meters out (see line layout in the figure to the left).

The EM302 was restricted to +/- 70 deg. swath width and all the lines were run in the Deep mode. The seep was detected on each pass and there did not appear to be any detection differences on the either the starboard or port swaths. Figures on the next two pages show the water column data for the seep detection as well as the range from the seep.
Water Column

Directly Across Seep

Line Offset By 450 meters

Seep Detection Assessment
Water Column

Seep Detection Assessment

Line Offset By 900 meters

Line Offset By 1350 meters
Seep Position Assessment

• Processing of the water column data has previously been done using the FM Midwater software. However, the geo-picked location of the seeps using that software were not correctly ray traced, therefore causing greater across track position uncertainty.

• The latest upgrades to the Qimera processing package have added the geo-picking option with ray tracing to the water column interface. As this is the correct method for determining location, it is intended that all future seep water column processing and geolocation will done using Qimera.

• This new approach to processing was tested during the NA093 and the figure to the left shows a plot of the seep positions determined using FM Midwater, Qimera, and navigation intern processing in FM Midwater. This plots reveals that there is significantly less uncertainty in the locations picked using Qimera.
Appendix 1 – Speed Noise Tests
Appendix 1 – Speed Noise Tests

E/V Nautilus EM302 Self Noise - Into Seas - 7 kts

E/V Nautilus EM302 Self Noise - Into Seas - 8 kts

E/V Nautilus EM302 Self Noise - Into Seas 7 kts

E/V Nautilus EM302 Self Noise - Into Seas 8 kts
Appendix 1 – Speed Noise Tests

E/V Nautilus EM302 Self Noise - Into Seas - 9 kts

E/V Nautilus EM302 Self Noise - Into Seas - 10 kts

E/V Nautilus EM302 Self Noise - Into Seas 9 kts

E/V Nautilus EM302 Self Noise - Into Seas 10 kts
Appendix 1 – Speed Noise Tests

E/V Nautilus EM302 Self Noise - Into Seas - 11 kts

[Graph showing self noise in dB re 1 μPa/√Hz across different channels.]

E/V Nautilus EM302 Self Noise - Into Seas 11 kts

[Histogram showing frequency distribution of self noise levels.]

Into Seas
Appendix 1 – Speed Noise Tests

With Seas

E/V Nautilus EM302 Self Noise - With Seas - 7 kts

Self Noise (dB re 1μPa/√Hz)

Channel

E/V Nautilus EM302 Self Noise - With Seas - 8 kts

Self Noise (dB re 1μPa/√Hz)

Channel

E/V Nautilus EM302 Self Noise - With Seas 7 kts

Frequency (%)

Self Noise (dB re 1μPa/√Hz)

Median
Mean (log.)
Mean (lin.)

E/V Nautilus EM302 Self Noise - With Seas 8 kts

Frequency (%)

Self Noise (dB re 1μPa/√Hz)

Median
Mean (log.)
Mean (lin.)
Appendix 1 – Speed Noise Tests

With Seas
Appendix 1 – Speed Noise Tests

With Seas

E/V Nautilus EM302 Self Noise - With Seas - 11 kts

<table>
<thead>
<tr>
<th>Channel</th>
<th>Self Noise (dB re 1\mu Pa/\sqrt{Hz})</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>16</td>
<td>40</td>
</tr>
<tr>
<td>32</td>
<td>50</td>
</tr>
<tr>
<td>48</td>
<td>60</td>
</tr>
<tr>
<td>64</td>
<td>70</td>
</tr>
</tbody>
</table>

Frequency (%)

<table>
<thead>
<tr>
<th>Self Noise (dB re 1\mu Pa/\sqrt{Hz})</th>
<th>30</th>
<th>35</th>
<th>40</th>
<th>45</th>
<th>50</th>
<th>55</th>
<th>60</th>
<th>65</th>
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<tbody>
<tr>
<td>Median</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Mean (log.)</td>
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<tr>
<td>Mean (lin.)</td>
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</tr>
</tbody>
</table>
Appendix 2 – Octagon Noise Tests
Appendix 2 – Octagon Noise Test

E/V Nautilus EM302 Self Noise - Octagon - 0 deg

\[ \text{Self Noise (dB re 1\mu Pa/Hz)} \]

\[ \text{Channel} \]

\[ 0 \quad 16 \quad 32 \quad 48 \quad 64 \quad 80 \quad 96 \quad 112 \]

E/V Nautilus EM302 Self Noise - Octagon - 45 deg

\[ \text{Self Noise (dB re 1\mu Pa/Hz)} \]

\[ \text{Channel} \]

\[ 0 \quad 16 \quad 32 \quad 48 \quad 64 \quad 80 \quad 96 \quad 112 \]

E/V Nautilus EM302 Self Noise - Octagon 0 deg

\[ \text{Frequency (%)} \]

\[ \text{Self Noise (dB re 1\mu Pa/Hz)} \]

\[ 0 \quad 5 \quad 10 \quad 15 \quad 20 \quad 25 \quad 30 \quad 35 \quad 40 \quad 45 \]

E/V Nautilus EM302 Self Noise - Octagon 45 deg

\[ \text{Frequency (%)} \]

\[ \text{Self Noise (dB re 1\mu Pa/Hz)} \]

\[ 0 \quad 5 \quad 10 \quad 15 \quad 20 \quad 25 \quad 30 \quad 35 \quad 40 \quad 45 \]
Appendix 2 – Octagon Noise Test

E/V Nautilus EM302 Self Noise - Octagon - 90 deg

E/V Nautilus EM302 Self Noise - Octagon - 135 deg

E/V Nautilus EM302 Self Noise - Octagon 90 deg

E/V Nautilus EM302 Self Noise - Octagon 135 deg
Appendix 2 – Octagon Noise Test
Appendix 2 – Octagon Noise Test

E/V Nautilus EM302 Self Noise - Octagon - 270 deg

E/V Nautilus EM302 Self Noise - Octagon - 315 deg

E/V Nautilus EM302 Self Noise - Octagon 270 deg

E/V Nautilus EM302 Self Noise - Octagon 315 deg
Appendix 2 – Octagon Noise Test

![Graph showing self noise levels for EV Nautilus EM302 with Octagon 360 deg configuration.](image)

- Self Noise (dB re 1μPa/Hz) vs Channel
- Frequency (%) vs Self Noise (dB re 1μPa/Hz)
- Graphs display data for median and mean (log. and lin.)
Appendix 3: SIS Configuration
Appendix 3: SIS Configuration

Installation Parameters
Appendix 3: SIS Configuration

Installation Parameters
Appendix 3: SIS Configuration

Installation Parameters
Appendix 3: SIS Configuration

Installation Parameters
Appendix 3: SIS Configuration

Installation Parameters
Appendix 3: SIS Configuration

Installation Parameters

- Clock
  - Source: Internal ZDA Clock
  - Offset (sec.): 0
  - 1PPS Clock Synch: Rising Edge

- 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

- Attitude Sensor Settings
  - Attitude Sensor Ports: COM2
  - Roll reference plane
    - Horizontal (ZMS)
    - Rotation (POSIM/MIMU)
  - Attitude Delay (msec.): 0

- Active Sensors
  - Positions: COM1
  - Attitude: COM2
  - Heading: COM2
  - Velocity: UDRPS
Appendix 3: SIS Configuration

Installation Parameters
Appendix 3: SIS Configuration

Installation Parameters
Appendix 3: SIS Configuration

### Runtime Parameters

#### Transmit Control
- **Pitch Stabilization**: On
- **Along Direction (deg.)**: 3
- **Auto bit**: ON
- **Yaw Stabilization**: Off
- **Mode**: REL MEAN HEADING
- **Heading Offset**: 0
- **Heading Filter**: MEDIUM
- **Min. Swath Dist. (m)**: 0.0
- **External Trigger**: Off
- **3D Scanning**: Off
- **Enable scanning**: On
- **Min. (deg.)**: 3
- **Max. (deg.)**: 3
- **Step (deg.)**: 0.0

#### Sound Speed Profile
- **Source**: SENSOR
- **Sound Speed (m/sec)**: 1522.2
- **Sensor Offset (m/sec)**: 0.0
- **Filter (sec):** 20

#### Depth Settings
- **Fence Depth (m)**: 740
- **Min. Depth (m)**: 100
- **Max. Depth (m)**: 4200
- **Dual swath mode**: DYNAMIC
- **Beam Mode**: AUTO
- **FM dictate**: Off

#### Sounder Main
- **Sound Speed**: [Profile]
- **Filter Gains**: [Profile]
- **Data Cleaning**: [Profile]
- **GPS and Delayed Heading**: [Profile]
- **Simulator**: [Profile]
- **Survey Information**: [Profile]
Appendix 3: SIS Configuration

Runtime Parameters
Appendix 3: SIS Configuration

Runtime Parameters
Appendix 4: Seapath Configuration
Appendix 4: Seapath Configuration
Appendix 4: Seapath Configuration
Appendix 4: Seapath Configuration

### NAV Engine Configuration

<table>
<thead>
<tr>
<th>Device</th>
<th>Device</th>
<th>Device</th>
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<tbody>
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<td>GeoSea</td>
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<tr>
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</tr>
</tbody>
</table>

**Max pitch and roll angles**
- Default: 15°

**Average pitch and roll angles**
- Default: 7°

**Gloness option**
- RTK and Float

**Enable SBAS test mode**
- Manual
Appendix 4: Seapath Configuration
Appendix 4: Seapath Configuration
Appendix 4: Seapath Configuration
### Appendix 4: Seapath Configuration

#### NAV Engine Configuration

**Input/Output list**

<table>
<thead>
<tr>
<th>Interface</th>
<th>Type</th>
<th>Direction</th>
<th>IOT Properties</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GS Multi</td>
<td>Serial</td>
<td>In/Out</td>
<td>NMEA 0183</td>
<td></td>
</tr>
<tr>
<td>GB Satcom</td>
<td>Serial</td>
<td>In/Out</td>
<td>NMEA 0183</td>
<td></td>
</tr>
<tr>
<td>GS Multi</td>
<td>Serial</td>
<td>In/Out</td>
<td>NMEA 0183</td>
<td></td>
</tr>
<tr>
<td>GNSS</td>
<td>Serial</td>
<td>In/Out</td>
<td>NMEA 0183</td>
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**Configuration details**

<table>
<thead>
<tr>
<th>Interface</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMEA</td>
<td></td>
<td>NMEA #1</td>
</tr>
</tbody>
</table>

**I/O properties**

- **Port**: COM12
- **Baud rate**: 4800
- **Data format**: NMEA HDT

**Advanced**

- **Checksum required**: N/A
- **Interval**: 0.10
Appendix 4: Seapath Configuration
# Appendix 4: Seapath Configuration

## NAV Engine Configuration

<table>
<thead>
<tr>
<th>Interface</th>
<th>Type</th>
<th>Direction</th>
<th>I/O Properties</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TelegramOut1</td>
<td>Serial</td>
<td>Dist</td>
<td></td>
<td>Attitude to EM102</td>
</tr>
<tr>
<td>TelegramOut2</td>
<td>Serial</td>
<td>Dist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TelegramOut3</td>
<td>Serial</td>
<td>Dist</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Configuration details

- **Interface**: TelegramOut
- **Type**: Ethernet
- **Cable ID**: 5001

### I/O properties

- **Broadcast**: Off
- **Unicast**: Off
- **Multicast**: Off

### Telegram out properties

- **Format**: Seapath binary
- **Datam**: YFO884
- **Monitoring point**: NPI

### Telegram timing

- **Interval [s]**: 0.010
- **Event driven**: Off
- **Timer driven**: On

---

Connected to Seapath 330+
Appendix 4: Seapath Configuration

### NAV Engine Configuration

#### Input/Output List

<table>
<thead>
<tr>
<th>Interface</th>
<th>Type</th>
<th>Direction</th>
<th>I/O Properties</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>COM13</td>
<td>Serial</td>
<td></td>
<td></td>
<td>Seapath Binary to MP1</td>
</tr>
</tbody>
</table>

#### I/O Properties

- **Port:** COM13
- **Baud rate:** 115200
- **M- or N:** M
- **R- or S:** R
- **NMEA:** GGA, HDG, VTG, ZDA
- **Log to file:**
- **Time precision:** 200

#### Telegram Out Properties

- **Format:** NMEA, Datum, YOBS4
- **Monitoring point:** MP1
- **Options:**
- **Internal [s]:** 1.000
- **Event driven:**
- **Timer driven:**

#### Configuration details

- **Interface:** TelegramOut
- **Type:** Serial
- **Direction:** Out
- **Serial communication:**
- **Data Rate:** 115200
- **Parity:** N
- **Stop bit:** 2
- **Character size:** 8
- **Flow control:**
- **Line end:** CR
- **TxD:**
- **RxD:**
- **Data Rate:** 115200
- **Parity:** N
- **Stop bit:** 2
- **Character size:** 8
- **Flow control:**
- **Line end:** CR
- **TxD:**
- **RxD:**

---

Connected to Seapath 330+
Appendix 4: Seapath Configuration
## Appendix 4: Seapath Configuration

### Seapath 330+ - Detailed Information

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Properties</strong></td>
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</tr>
<tr>
<td>OS image build no</td>
<td>3</td>
</tr>
<tr>
<td>OS Image built</td>
<td>2011-09-20</td>
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<tr>
<td>Operator SW version</td>
<td>8.01.01 - 48</td>
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<tr>
<td>Operator SW built</td>
<td>2016-04-28 09:33:08</td>
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<tr>
<td>DataPool client version</td>
<td>2.0</td>
</tr>
<tr>
<td>DataPool server version</td>
<td>2.0</td>
</tr>
<tr>
<td>Processing SW version</td>
<td>4.11.05</td>
</tr>
<tr>
<td>Processing unit OS</td>
<td>Linux</td>
</tr>
<tr>
<td>HP lib version</td>
<td>HP 7.14b</td>
</tr>
<tr>
<td>IMU type</td>
<td>Kongsberg Seatex, MRU 5.x Ser 20230 Quality 1</td>
</tr>
<tr>
<td>ONSS 1 type</td>
<td>Novatel, OEMV</td>
</tr>
<tr>
<td>ONSS 1 firmware</td>
<td>L12GV.BIZ133026 OEM2G-5.00-10.012013MM/14142201</td>
</tr>
<tr>
<td>ONSS 2 type</td>
<td>Novatel, OEMV</td>
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<tr>
<td>ONSS 2 firmware</td>
<td>L1G DES11 200114 V1G-1.04-IT 3.006 3.010 2013/14 142201</td>
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<td>IMU firmware</td>
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</table>

### Assemblies

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
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<td>IMU firmware</td>
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<td>Assemblies</td>
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<td>Accessibility.dll</td>
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<td>log4net.dll</td>
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<tr>
<td>mscorlib.dll</td>
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<td>SeapathHMI EXE</td>
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<tr>
<td>stuApplicationFW.dll</td>
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<td>StxDapNSwEngineFW.dll</td>
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<tr>
<td>StxDapSwLibFW.dll</td>
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<tr>
<td>StxHmiLib.dll</td>
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<tr>
<td>StxInfraStructure35 dll</td>
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<tr>
<td>System.Configuration.dll</td>
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<tr>
<td>System.Core.dll</td>
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<tr>
<td>System.dll</td>
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</tr>
<tr>
<td>System.Drawing.dll</td>
<td>2.0.507.27</td>
</tr>
</tbody>
</table>
## Appendix 4: Seapath Configuration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>mscotlib.dll</td>
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<tr>
<td>Seapath3.exe</td>
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<td>StdDapNavEngFw.dll</td>
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<td>StdDapSwLibFw.dll</td>
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<tr>
<td>StdHimLib.dll</td>
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<tr>
<td>StdInfrastructutre35.dll</td>
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<tr>
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<tr>
<td>System_Management.dll</td>
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<td>System_ServiceProcess.dll</td>
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<td>System_Windows_Form.dll</td>
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<td>System_Xml.dll</td>
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</tbody>
</table>
Appendix 5 – Sound Speed Manager Configuration
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