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R/V Kilo Moana Multibeam Echosounder System Review

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R/V Kilo Moana Multibeam Echosounder System Review
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Multibeam Advisory Committee
Sea Acceptance Team

July 1st, 2012

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Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.
Introduction

R/V *Kilo Moana* undertook a series of sea acceptance and acoustic noise trials in support of the vessel’s EM710 and EM122 multibeam echosounders in the vicinity of Oahu from June 21-24, 2012, see Fig. 1. Jonathan Beaudoin, Tim Gates and Marisa Yearta participated in the cruise (KM1212) as part of the NSF funded Multibeam Advisory Committee (MAC) project, an effort to improve the data quality from multibeam echosounders in the U.S. academic fleet. Gates and Yearta form the MAC’s Acoustic Noise Team (ANT); Beaudoin was there as a representative of the Sea Acceptance Team (SAT), normally headed by John Hughes Clarke who was unavailable due to a conflicting commitment.

Sea trials were initially planned for March of 2012 but these were postponed due to delays in the shipyard where the receiver array for the vessel’s EM122 was replaced and the new EM710 was installed. Initial assessments out of the shipyard indicated that the EM710 was functioning as expected, however, it was quickly determined that the EM122 was underperforming and that manufacturer intervention was required (Beaudoin and Johnson, 2012).

Between the March and June cruises, the manufacturer visited the ship on three separate occasions in order to resolve the problems with the EM122. At the MAC’s request, ship personnel kept the MAC informed of progress and findings along the way, with Beaudoin and Johnson providing independent data assessments as necessary to help in the trouble-shooting process. During the last trouble shooting session aboard the vessel, a Kongsberg technician found the problem: three of the eight receiver modules were incorrectly wired and had reverse polarity. Initial assessments by the technician at sea indicated that the EM122 was operating at full capacity and was ready to be tested during the scheduled sea acceptance trials.

Given (1) the disappointing performance of the EM122 out of the shipyard, (2) the last minute resolution of the problem by the manufacturer and (3) the compressed schedule of the sea acceptance trials, the trials understandably focused on confirming the performance of the EM122 even though it was not nominally subject to a formal sea acceptance trial like the new EM710.

Cruise activities were limited to calibration, accuracy and coverage testing of the EM710 and EM122 systems, these being intermingled with acoustic noise measurements by Gates and Yearta. It is the intent of this report to document the findings of the EM710 and EM122 evaluations only though references may be made to preliminary findings of the acoustic measurements as they pertain to the multibeam echosounder systems’ performances. The results of the acoustic testing are reported separately by Gates and Yearta.
Figure 1. Area of operations for EM122/EM710 sea acceptance trials (map prepared from GMRT via GeoMapApp).

**EM122**

**Calibration**

A standard patch test calibration routine was performed in ~4,850 m of water over a ridge ~600 m proud of the seafloor, located approximately 20 NM south of the westernmost tip of Penguin Bank (Fig. 2). The west side of the ridge presented a sharp slope with a 600 m change of depth occurring over a distance of 1,000 m. Calibration lines were run perpendicularly to the ridge over a period of eight hours. An XBT profile was acquired prior to the calibration lines and was processed using the MAC SVP Editor (Beaudoin, 2012) and uploaded to the EM122 for use in real-time ray tracing corrections. Due to the constrained testing schedule, there was insufficient time to run verification lines, however, it was felt that errors in calibration would be apparent in the accuracy testing that immediately followed the calibration.
Figure 2. EM122 calibration site. Location map (upper left) with an inset map showing the ridge feature used for calibration (upper right). The bottom plot shows the depth profile over the ridge, corresponding to the yellow line in the upper right map. The flat area to the west of the ridge was used for roll calibration (not fully shown).

Calibration lines were processed by the Kongsberg Maritime technicians and were independently verified by Beaudoin using the UNB/OMG SwathEd software suite. Results of the patch test are summarized in Table 1. Angular offsets were entered into SIS into the MRU fields, leaving the sonar angular offset fields as they were prior to the trials.

Table 1. EM122 Calibration Results.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRU Roll</td>
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<td>MRU Pitch</td>
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<tr>
<td>MRU Heading</td>
<td>0.06°</td>
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<tr>
<td>Navigation time latency</td>
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</table>

Accuracy
A deep-water accuracy test was conducted in 4,700 m depth in an area that has seen multiple previous examinations of EM122 system on other vessels (Fig. 3). Located approximately 45 NM west of Oahu, the area presents a flat and relatively featureless seafloor. Survey lines used on previous accuracy tests from other EM122 equipped vessels were re-run over a period of approximately 18 hours with a line spacing of 4,000 m yielding between 200-300% coverage. Survey speed was held at 8 kts for both main and cross lines. The EM122 was configured to run in dual-swath, “Deep” mode with CW pulses for the innermost four sectors and FM pulses for the two outermost sectors on each side (for a total of four FM sectors). The angular sector was set in automatic mode with limits at +/-70°. Cross lines were run in the orthogonal direction with the same sonar settings and vessel speed. Five XBT casts were performed throughout the survey, these were processed using the MAC SVP Editor (Beaudoin, 2012) and applied immediately.

A reference surface was prepared from the main survey lines using a 1.0° beamwidth radius of influence and a linear beam-weighting scheme for the innermost 300 beams (the outer most 70 port and starboard beams were not included in the construction of the grid). A slope filter of 1.5° was used to mask areas of high topography for the purpose of the cross line statistical analysis.

Cross lines soundings were compared on a beam-by-beam basis against the reference surface with statistics being compiled by sector and swath number, see Fig. 4. Note that “swath number” refers to the swath number in the dual-swath geometry, i.e. swath 1 of 2 and swath 2 of 2. Results were collated into 1° bins with the mean bias and standard deviation about the mean calculated for each bin. On average, the system is unbiased across the majority of the swath with a slight refraction like artifact in the outer edges of the swath. The standard deviation increases with swath angle (Fig. 5) with a ~50% increase in uncertainty associated with the crossover angle from the outermost CW sector to the innermost FM sector, between 30°-35°. The observed mean biases and standard deviations are within the
expected achievable abilities of the system as a whole. Behavior is consistent from swath to swath in the dual swath geometry.

Figure 4. Point cloud of beam depth differences by angle for all four cross lines. Mean differences per 1° bin are plotted as solid lines with color variations by angle indicating sector and color variation within sector signifying swath number in the dual-swath geometry (blue-red is swath 1 of 2, magenta-cyan is swath 2 of 2). Standard deviations about the mean bias are plotted by swath and sector number as dashed lines; these are also plotted in Fig. 5.
Summary statistics, such as those presented in Figs. 4 and 5, provide only a limited view of the system’s performance. Bias images were prepared to allow for spatial representation of bias across the swath for all pings in each of the four cross lines (Fig. 6). There is no evidence of data integration errors, e.g. motion delay or incorrect linear offsets. There is evidence of a small residual roll offset based on the asymmetry of the bias on the port and starboard sides (reds on one side, greens on the other). The offset is approximately -0.05° for a total recommended MRU offset of -0.10°. The outer FM sectors do not exhibit “wobbles” as seen in previous analyses by this author (USNS Mary Sears EM122 trials, April 2012); this could be due to a low sea state and/or the inherent stability of Kilo Moana’s SWATH design.
Seabed Imagery

The main/cross lines used to assess the bathymetric repeatability were used to examine the backscatter offsets using similar methods. Prior to analysis, the Kongsberg time-varying gain (TVG) that is applied to the data in real-time for angular normalization was removed such that remain imagery biases were solely due to sector and swath number specific offsets (Kongsberg, 2000).

A reference seabed imagery mosaic strip was chosen along a narrow corridor with a single main line contributing to the mosaic with an incidence angle of roughly 25°. Seabed imagery data (center sample from each beam snippet) from the cross lines were differenced against the reference mosaic with results tabulated by sector and swath (Fig. 7), similar to what was done for the bathymetric analysis.

Figure 6. Sounding bias images in ping/beam geometry images for four cross lines (ping number is vertical axis, beam number is horizontal axis). Note that data holidays are due to intentional masking of high topography areas.
Referring to Fig. 7, slight sector signal offsets (1-2 dB) are observed in Deep mode, these are typical of this system and can be calibrated by updating a calibration file on the EM122 TRU (bscorr.txt). No strobing was observed between swaths in dual-swath mode, indicating that sector source levels are well compensated between swaths in dual-swath “Deep” mode.

**Figure 7.** Seabed imagery bias analysis results. The biases capture the effect of the seafloor’s angular response and the sector/swath specific offsets. Color-coding is by sector and swath (blue-red is swath 1 of 2, magenta-cyan is swath 2 of 2). Biases are relative to an incidence angle of 25°.

**Coverage**

As mentioned in the introduction, the coverage achieved by the EM122 during the transit out of the shipyard in March, 2012 was very poor (see Fig. 8). As the performance of the EM122 was the primary concern of these trials, the coverage was monitored throughout the entire trial; results are plotted in Fig. 9. Other than an accidental misconfiguration of the system into “Mammal Protection Mode”, the EM122 was able to achieve full sector coverage in shallow water depths and achieved just less than 4x w.d. during the deep water accuracy testing (roughly equivalent to an angular sector of +/-63°). The improvement in coverage achieved by the EM122 indicates that the problems identified during the March transit had indeed been rectified by the manufacturer. High transit speeds (with port engines
running, the noisiest possible configuration) gave sub-optimal coverage up and down the various slopes due to the elevated noise levels. The Gates and Yearta report discusses optimal ship configurations for low noise levels. It should be noted that the deep water accuracy testing was done at lower vessel speeds (8 kts) with only the starboard engines running (the lowest noise configuration profile of the vessel). The 16-20 km coverage achieved in 4,700 m water depth in Fig. 9 is from the deep accuracy test and is indicative of what the system can achieve in low noise settings. Higher seafloor backscatter will likely yield increased coverage.

Figure 8. For reference, plot of poor swath coverage achieved during KM1204 cruise (Portland, OR to Honolulu, HI in March 2012). EM122 nominal coverage in 1°x2° mode is grey/purple. See (Beaudoin and Johnson, 2012) for more discussion.
The coverage achieved by *Kilo Moana*'s EM122 is often compared to that which is achievable by the EM122 systems installed on the U.S. Naval Oceanographic Office (NavO) TAGS vessels. Examples of coverage achieved by two such systems are shown in Fig. 10. Whereas *Kilo Moana* was achieving 4.0x w.d. in 4,700 m of water, the NavO vessels achieved approximately 4.5-5.0x w.d. Note that the plot of Fig. 9 shows a point cloud of all outer most beam solutions acquired during the course of the deep accuracy test at a depth of 4,700 m. The plots of Fig. 10, on the other hand, show ALL soundings across the swath and it is difficult to assess what the mean coverage is since the inner soundings mask the distribution of the outermost soundings. A fair comparison is to compare the maximum coverage achieved by *Kilo Moana*, in this case perhaps 4.0x w.d. at 4,700 m depth, to the edge of the NavO coverage at the same depth, perhaps 4.5x w.d.
Figure 10. Coverage achieved by two EM122 systems on USNS Pathfinder and USNS Heezen during sea acceptance trials out of Saipan. The depth of 4,700 m is highlighted for comparison of coverage achieved by Kilo Moana during deep-water accuracy testing in the same water depth. Figures adapted from plots provided by Dr. John Hughes Clarke of the SAT team.

The increased coverage achieved by the NavO vessels can be explained by (1) a lower acoustic noise levels (typically <45 dB), and (2) the increased directivity of the 1° receiver array (compared to Kilo Moana’s 2° receive array). These two combine to give a higher signal to noise ratio on the NavO vessels. Sonar coverage simulations performed by Dr. Xavier Lurton, of Ifremer, explain the observed differences in coverage performance. Simulations were run with the following parameters:

**Frequency:** 12 kHz  
**Oceanographic conditions:** typical temperature/salinity profile at the latitude of Honolulu and Saipan (the NavO EM122 testing ground for the TAGS vessels)  
**Required Signal-to-Noise (SNR) for successful detection:** 10 dB  
**Seafloor backscattering strength:** -30 dB at vertical incidence, Lambertian response  
**Noise Level for Kilo Moana @ 8 kts:** 50 dB, based on recent measurements  
**Noise Level for NavO vessel @ 8 kts:** 42 dB, based on recent measurements from USNS Mary Sears  
**Transmit/Receiver beamwidth for NavO vessel:** 1°x1°  
**Transmit/Receiver beamwidth for Kilo Moana:** 1°x2°

The NavO vessel gains 3 dB in SNR due to the increased receiver array directivity. This alone can increase the achievable swath by roughly 5%. The difference in acoustic noise levels brings an additional 8 dB of SNR for a total of 11 dB SNR difference between a typical NavO installation and Kilo Moana.
Predicted performance from Lurton’s model indicate that *Kilo Moana* should achieve approximately 19 km of swath at 4,700 m, refer to the “Nominal” coverage curve in Fig. 11. The model predictions are consistent with what was observed in the sea acceptance trials despite approximations regarding the seafloor’s exact angular response and the system’s unknown transmit beam patterns. The typical NavO platform, which enjoys an additional 11 dB of SNR, would achieve approximately 23.5 km of swath under the same conditions (refer to the “+10 dB” curve in Fig. 11). Again, the model predictions are consistent with the NavO coverage plots of Fig. 10.

The difference in coverage between the two systems is an additional 4.5 km in 4,700 m of water. Expressed in multiples of water depth, this gives an additional 1.0x w.d. of coverage relative to what *Kilo Moana* can achieve. Note that the noise levels in Lurton’s analysis are assumed for the NavO vessels since the speed at which the data were acquired was not readily known at the time of this writing.

The model results confirm that the discrepancy in coverage between the platforms is explainable by, in order of potential impact, the differing platform acoustic noise levels and receiver directivities. The model results also indicate that that *Kilo Moana*’s EM122 is performing exactly as it should be in terms of achievable coverage. Further gains in coverage can only be obtained through improvements to the acoustic noise levels.
EM710

Calibration

A standard patch test calibration routine was performed in ~460 m of water over a ridge ~70 m proud of the seafloor, located approximately 2.7 NM northwest of the northwestern rise of Penguin Bank. Calibration lines were run perpendicularly to the ridge over a three-hour period (Fig. 12). An XBT profile was acquired prior to the calibration lines and was processed using the MAC SVP Editor (Beaudoin, 2012) and uploaded to the EM710 for use in real-time ray tracing corrections. Verification lines were only run for roll and pitch due to the short amount of time required in the relatively shallow water.

Figure 12. EM710 patch test calibration site. Location map (upper left) shows general location, inset map (upper right) shows ridge feature. The lower plot shows the depth profile over the ridge; this corresponds to the yellow line in the inset map in the upper right.

Calibration lines were processed by the Kongsberg Maritime technicians and were independently verified by Beaudoin using the UNB SwathEd software suite. Results of the patch test are summarized in Table 2. Angular offsets were entered into SIS into the MRU fields, leaving the sonar angular offset fields as they were prior to the trials.
Table 2. EM710 Calibration Results.

<table>
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<td>Navigation time latency</td>
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**Accuracy**

Accuracy testing for the EM710 was conducted just offshore of Honolulu on a slightly sloping seafloor with depths ranging from 490-530 m (Fig. 13). Main survey lines ran from SE to NW and were 5.4 NM long with a 500 m line spacing and a vessel speed of 8 kts. Three cross lines were run perpendicular to the main lines. An XBT was acquired shortly before arriving onsite with a second collected midway through acquisition of the main lines. Both were processed using the MAC SVP Editor and were applied immediately. The EM710 was configured to run in “Deep” mode with dynamic dual swath and FM pulse waveforms enabled for both the main and cross lines. One of the cross lines was run a second time in “Very Deep” mode.

![Figure 13. Location map for EM710 accuracy testing.](image)

It was noted during acquisition that a refraction artifact persisted despite having a recent XBT cast immediately uploaded into the multibeam acquisition system (SIS). Both XBT temperature profiles were nearly identical and the surface sound speed probe was suspected of bias. This was determined not to be the case since re-application of potential negative and positive corrections to surface sound speed using UNB/OMG SwathEd software introduced roll dependent wobble artifacts (this is an indication that the surface sound speed was correct in the first place, see
(Hughes Clarke, 2003)). It is thought instead that the salinity augmentation provided by the World Ocean Atlas was inadequate for this particular case though this could not be confirmed since the thermostalinograph was not operational at the time of the survey and the surface salinity could not be compared to the WOA mean salinity. An alternate sound speed profile was interactively modified to correct the sounding data using UNB/OMG Soundscape software. The required sound speed corrector in the sound speed profile corrected for an apparent 1.3 m/s sound speed bias over the profile; this is loosely equivalent to a salinity bias of 1 psu spread over the profile. The modified profile was subsequently used to correct the refraction artifact in the main line data using UNB/OMG SwathEd sounding reduction algorithms for multi-sector multibeam echosounders (Beaudoin et al., 2004). The corrected profile was converted to Kongsberg .asvp format and uploaded to SIS and applied prior to acquisition of the cross lines such that they did not suffer from the artifact. Typically, a CTD cast is acquired to do this type of analysis but the lack of time for these trials precluded lengthy operations such as CTDs, especially for the deep water in which the EM122 was calibrated and tested.

The reference surface was created with a 1° beamwidth radius of influence, using only the portion of the surface that fell within the bounds of the survey lines to ensure as much redundancy as possible in the surface. The “Deep” mode on the EM710 uses FM waveforms for the outermost sector and CW for the sectors for a total of three sectors. As will be shown, the FM sectors typically suffer from additional noise possibly due to imperfect correction for Doppler shift of the signal during transmission and reception. For this reason, the reference surface creation used a linear weighting scheme that assigned nearly negligible weight to the beams falling in the outermost FM sectors. A slope filter of 1.5° was used to mask areas of high topography for the purpose of the cross line statistical analysis.

Cross lines soundings were compared on a beam-by-beam basis against the reference surface with statistics being compiled by sector and swath number, see Fig. 14. Note that “swath number” refers to the swath number in the dual-swath geometry, i.e. swath 1 of 2 and swath 2 of 2. Results were collated into 1° bins with the mean bias and standard deviation about the mean calculated for each bin. There are slight sector biases that can be explained by what appears to be a slight roll offset residual. The starboard outer FM sector appears to have a slight positive bias (meaning it tracks slightly too deeply on average) relative to its neighboring CW sector in the center. The standard deviation increases with swath angle (Fig. 15) with a 50% increase in uncertainty associated with the crossover angle from the outermost CW sector to the innermost FM sector at 40°. There was noticeable nadir mistracking with the system, leading to increased sounding uncertainty in this region. This is due to the system being forced into "Deep" mode when it would have selected “Very Deep” mode had it been running in Auto mode where the system chooses an appropriate mode based on the depths it encounters. The observed mean biases and standard deviations are within the expected achievable abilities of the system as a whole. Overall behavior is also consistent from swath to swath in the dual swath geometry.
Figure 14. Point cloud of beam depth differences by angle for all three cross lines run in "Deep" mode. Mean differences per 1° bin are plotted as solid lines with color variations by angle indicating sector and color variation within sector signifying swath number in the dual-swath geometry (blue-red is swath 1 of 2, magenta-cyan is swath 2 of 2). Standard deviations about the mean bias are plotted by swath and sector number as dashed lines; these are also plotted in Fig. 15.
Cross lines were also run in “Very Deep” mode, which differs from “Deep” mode in that FM pulse waveforms are used for all sectors and that dual swath is no longer available. Sounding biases are shown in Fig. 16 with the usual mean and standard deviation color coded by sector. Note that the inner sector uncertainty has increased relative to the inner CW sector of “Deep” mode in Fig. 15 and that the step increase in sounding uncertainty is no longer present at the sector boundary (Fig. 17). Also evident in the mean biases of Fig. 16 is the effect of the unresolved roll offset. The higher SNR associated with the use of FM waveforms for the central sector allows for improved bottom detection near nadir and the spikes in sounding uncertainty observed in “Deep” mode (Fig. 15) are no longer present. The slight increase in uncertainty observed at +/-10° is associated with the transition from amplitude to phase bottom detections; this is also apparent in “Deep” mode (Fig. 15). As with “Deep” mode, the observed mean biases and standard deviations are within the expected achievable abilities of the system as a whole.
Figure 16. Point cloud of sounding biases for "Very Deep" mode. Mean differences per 1° bin are plotted as solid lines with color variations by angle indicating. Standard deviations about the mean bias are plotted by swath as dashed lines; these are also plotted in Fig. 17.
Figure 17. Sounding uncertainty as a function of beam angle for “Very Deep” mode. Color-coding indicates sector number. Note that all sectors in this mode use FM pulse waveforms.

As with the EM122, the spatial distribution of sounding bias is investigated through preparation of bias images (Fig. 18). The three cross lines do not exhibit any spatially coherent patterns that would be indicative of incorrect sensor integration. Of particular note is the dramatic increase in the amount of incoherent sounding bias in the outer FM sectors in the first three cross lines (recall that this is associated with the increase in sounding uncertainty at 40° in Fig. 15). The cross line run in “Very Deep” exhibits a slight wobbling, in the central sector only, of about 0.5 m (0.1% w.d.).
Seabed Imagery

As was done for the EM122, an analysis was done to assess the sector signal level offsets in seabed imagery. A small reference mosaic corridor was constructed over a featureless corridor of seafloor that was ensonified at an incidence angle of 50°-57° by one of the main lines. The Kongsberg real-time normalization (Kongsberg, 2000) was not removed due to difficulties in processing that could not be resolved immediately. Beam-by-beam signal level differences were estimated by differencing the beam seabed imagery data (center sample in each beam’s imagery time-series) against the reference mosaic (Fig. 19). The third cross line, at the northern edge, was omitted from the analysis due to the high variability in seafloor response in this...
area of the accuracy test site. This also prevented analysis for the “Very Deep” mode of the system as the last cross line for this mode repeated the line used for the third cross line.

Figure 19. Sector signal level offsets affecting seabed imagery data. These are partially contaminated by the Kongsberg real-time normalization due to difficulties in the removal of the real-time normalization (Kongsberg, 2000).

Offsets between sectors are small, typically less than 1 dB. Strong beam pattern artifacts are observed in the outer most FM sectors, however, these can also be attributed to the real-time normalization scheme used by Kongsberg. The EM710 does not currently support real-time beam pattern correction and sector/swath balancing as can be done with the EM122 via the TRU configuration file (bscorr.txt). It is the author’s understanding that the manufacturer is currently working on adding this ability to the EM710 and it may be available in future system upgrades.

Coverage

The swath coverage abilities of the EM710 were tested by logging as much of the transit data as possible, water depth permitting, and plotting the outermost detected port and starboard sounding as was done previously with the EM122, refer to Fig. 20. The system was able to track the full angular sector to a depth of 500 m; this is consistent with its observed abilities during the March transit from Portland, OR to Honolulu, HI (Beaudoin and Johnson, 2012). This is also consistent with other
EM710 systems on NavO vessels though the exact depth where EM710 systems become attenuation limited will vary with bottom type. Extinction for the system was reached at ~1,800 m. The coverage performance is within the range of what is expected for this system and the findings from these trials indicate that the system is functioning at its fullest capability.

![EM710 Coverage](image)

**Figure 20.** Coverage achieved with EM710.

**Summary and Recommendations**

The EM122 and EM710 systems both appear to be configured correctly and, for the most part, adequately calibrated. Small MRU roll alignment residuals do exist and it is recommended that these be confirmed as soon as possible through acquisition of a pair of reciprocal survey lines over a flat and featureless seafloor. Verification lines should have been run for calibration tests for both systems, however, time constraints on the cruise schedule precluded this. It is standard practice to run verification lines.

The EM122 performance issues appear to have been resolved: 3 of 8 RX modules were wired with reverse polarity, Kongsberg Norway has issued a software patch to reverse the polarity in software prior to beamforming. It is the author’s understanding that a set of jumper cables are in the process of being made to fix the
changing its IP address currently configured.

The real either through SIS or through the Applanix POS/MV monitoring software. Logging/archival procedures should be established for Applanix “True Heave” DGPS, and likely require: (1) For optimal data quality, EM710 operations in shallow, continental shelf waters will likely require: (1) GPS differential corrections provided to the POS/MV, at least DGPS, and perhaps (2) application of Applanix “True Heave” in post-processing. Processing procedures for “True Heave” should be investigated as well to allow for real-time QA/QC by technicians and/or cruise participants.

The datagram distribution service can potentially overload the EM710 TRU as it is currently configured. It is recommended to remove duplicate datagram subscriptions for the two HMRG Seafloor Mosaic Display systems; the redundancy provided by the two HMRG systems could be kept in place with the backup system changing its IP address in event of a failure of the primary HMRG machine. The
removal of duplicate datagrams subscriptions should be repeated for the EM122. On a technical note, it was observed that the EM710 Hydrographic Work Station (HWS) is reporting SMART errors for the primary hard drive (C:). This drive should be backed up and replaced ASAP.

Knowledge of multibeam data transfer/archival scripts implemented by the MAC (P. Johnson) during Portland/Honolulu transit in March 2012 has not been adequately transmitted to OTG technicians in crew change handovers. These should be internally documented and explained to all staff.

Coverage performance of the EM122 is as expected and is consistent with Lurton’s model predictions. In its current configuration, gains in coverage can only be made by reducing acoustic noise levels. There is much focus on the achievable coverage for these systems as this is the metric with which many science personnel judge the capabilities of a system. It should be pointed out that the sounding uncertainty at the outermost edges of the swath, perhaps at 70°, can be nearly an order of magnitude larger than what is achievable at nadir (see Fig. 5). Though it is tempting to wish for a system that can image over a larger sector, the additional data that are gained are typically of very poor quality and would likely be omitted from any scientific analysis on the data. Clearly, other methods and metrics are required to report the useable swath width. For example, Ifremer measures the coverage of their multibeam systems by the swath width that exhibits less than 0.3% w.d. sounding uncertainty at the 95% confidence level. For the EM122 investigation done in this work, this would be equivalent to a sector of +/-50° in “Deep” mode in 4,700 m of water (this will vary, of course, with depth). This gives a much more realistic and practical measure of the useable swath width.
References


