# R/V *Sally Ride*

*EM124 SAT & EM712 QAT*
*Multibeam Echosounder*
*Quality Assurance Testing*
*April 4-5, 2023*
*SR2307*

*Multibeam Advisory Committee*
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*Supported under NSF Grant No. 1933720*

*photo: SIO*

# Executive Summary

1. The R/V *Sally Ride* (SR) conducted routine quality assurance testing (QAT) on April 4-5, 2023, following the ship's winter maintenance period

2. The primary QAT activities included mapping system configuration review and calibration ('patch testing') at two sites near San Diego, CA:

   a. EM712 calibration at a proven site used repeatedly by SIO and other vessels

   b. EM124 calibration at a new site southwest of San Clemente Island; this site was developed in order to reduce transit time compared to an EM122/124 site used previously (see SR2101 SAT report for details)

3. The Multibeam Advisory Committee (MAC) assisted with test planning, configuration review, and data processing in collaboration with SIO and SR personnel

4. Planning followed the standard MAC SAT checklist, starting with hardware health, RX noise testing, and calibration; additional testing (e.g., accuracy and swath coverage) was limited by schedule constraints

# Executive Summary

5. The EM124 and EM712 calibrations were conducted using post-SR2104 configurations; the results were zero for all but one test (also a small result), indicating stable and consistent mapping system configuration

6. The current settings should be maintained until any mapping sensors are modified or another calibration becomes necessary for other reasons (e.g., seasonal readiness testing)

7. EM124 TX Channels BISTs indicated two channel failures since August 2022; while this remains a very low failure rate (out of 864 channels), routine BISTs should be conducted to monitor for additional failures

8. RX noise vs. speed testing revealed a significant increase in EM124 noise levels since SR2104, presenting a risk of swath coverage and accuracy degradation; because the speed range was limited to 6-9.5 kts in the test data, it is not clear whether the increase is due primarily to higher machinery noise levels that are present at all speeds or other speed- and flow-related impacts (e.g., from biofouling) that may be reduced at low speeds

9. No EM712 BISTs were available due to errors in continuous logging; this issue was reported to Kongsberg

10. The MAC is available to assist with EM124 noise level troubleshooting and processing additional EM712 BISTs when logging is restored

# Survey System Components

The primary mapping system components are:

1. Kongsberg Maritime EM124 multibeam echosounder (12 kHz, 1.0° TX x 2.0° RX), s/n 10027
2. Kongsberg Maritime EM712 multibeam echosounder (40-100 kHz, 0.5° TX x 1.0° RX), s/n 10003
3. Kongsberg Maritime Seafloor Information System (SIS), v5.11
4. Kongsberg Seapath 330+ navigation system
   a. NovaTel GNSS antennas
   b. Kongsberg Seatex MRU 5+
5. Valeport surface sound speed sensor
6. Turo Quoll XBT sound speed profiling system
7. Seabird SBE 9 CTD profiling system

# System Geometry Review

## Overview: History

The term ‘system geometry’ means the linear and angular offsets of the primary components of the multibeam mapping systems, including the transmit arrays (TX), receive arrays (RX), GNSS antennas, and motion sensors (MRU/IMU). The following table provides an overview of the system geometry history.

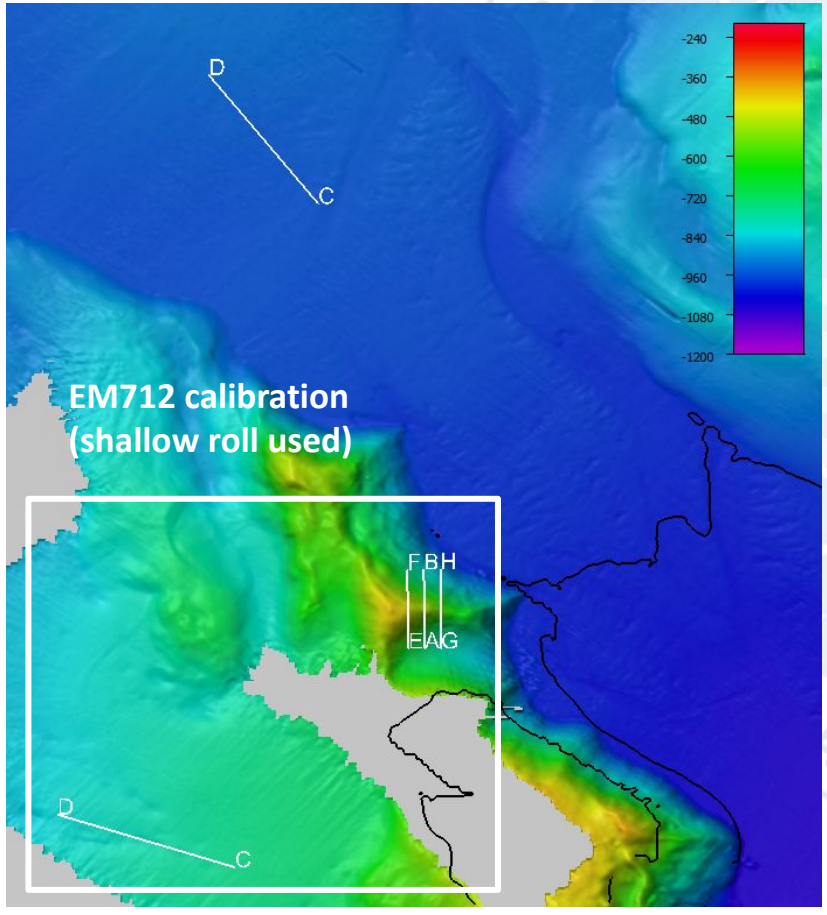
| Date | Location | Event | References |
|---|---|---|---|
| **2016-04-05 to 2016-05-06** | Anacortes, WA | IMTEC survey to establish vessel reference frame and offsets of EM122/EM712 arrays, Seapath MRU, iXBlue MRU, and GNSS antennas; offsets reported in Kongsberg convention with origin at top/stbd/aft corner of reference plate (note: not granite block); this survey used the granite block as the baseline (note: some differences in 2021 survey due to change of baseline) | IMTEC survey report provided by R/V *Sally Ride* (see SR1601 QAT report) |
| **2016-07-25 to 2016-07-28** | Anacortes, WA | SR1601 quality assurance testing; calibration of EM122 and EM712 with Seapath primary position/attitude system | SR1601 QAT report |
| **2021-05-12 to 2021-05-27** | Alameda, CA | IMTEC survey to re-establish vessel reference frame with keel as baseline and existing EM122/EM712 arrays, new SBP29 TX array, Seapath MRU, HYDRINS MRU, and GNSS antennas; offsets reported in Kongsberg convention with origin at top/stbd/aft corner of reference plate; *note same origin as 2016 survey but different baseline for vessel fit, resulting in some differences of up to ~10 cm in reported offsets between 2016 and 2021 reports* | IMTEC survey report (Rev. 2) provided by R/V Sally Ride |
| **2021-06-27 to 2021-07-07** | Alameda to San Diego, CA | EM124 SAT (topside upgrade from EM122) and EM712 QAT; system geometry review, Seapath antenna calibration dockside, EM124 / EM712 patch tests, coverage testing, and accuracy assessments; EM124 baseline hardware health and noise testing; SBP29 SAT (not reported here) | SR2104 SAT report |
| **2023-04-05 to 2023-04-06** | San Diego, CA | Configuration review; EM124 and EM712 calibration (‘patch test’) | This document |

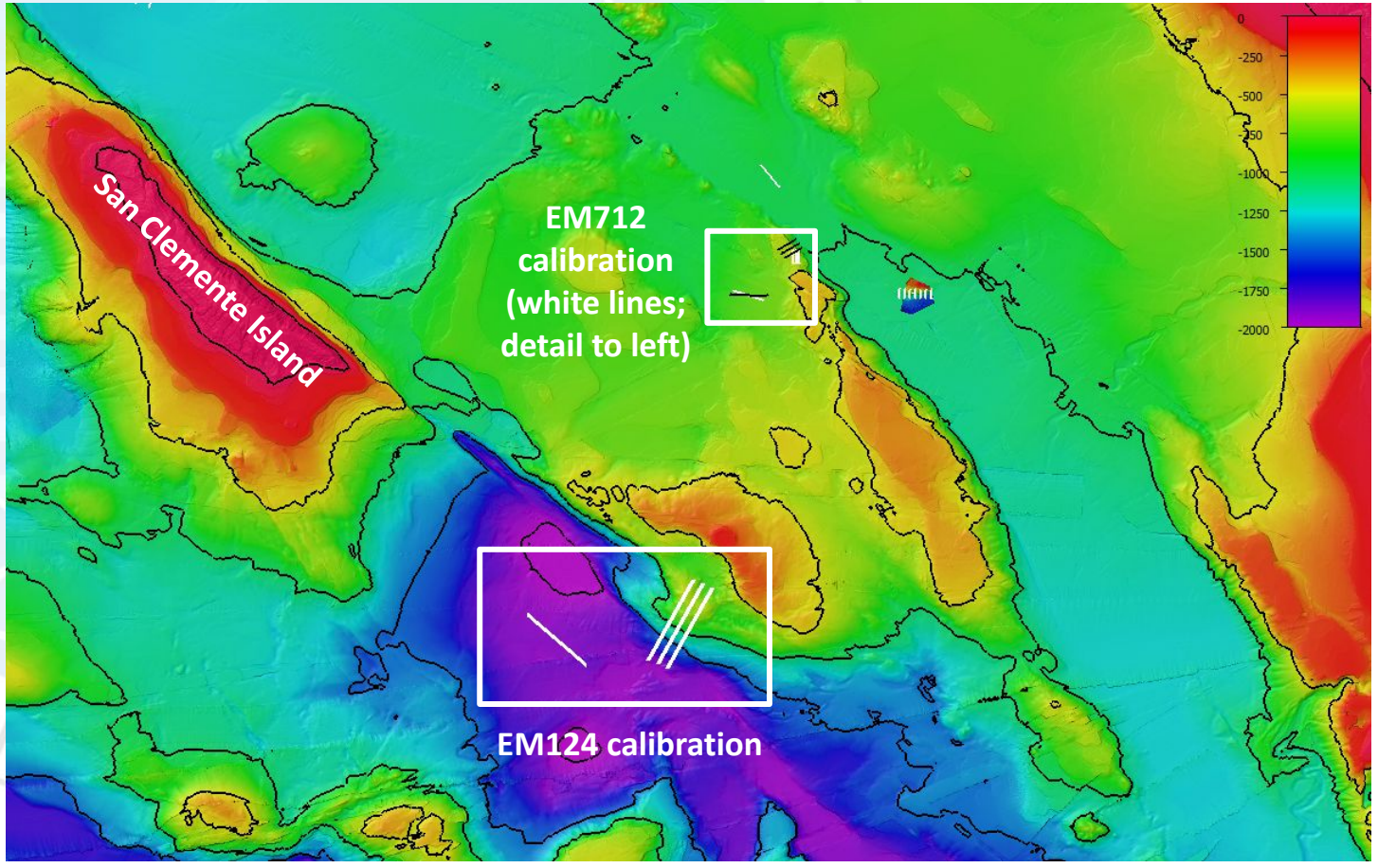
# Planning Overview

1. Calibrations were planned off San Diego at two sites selected to minimize transit time:

   **EM712:** a proven site used repeatedly by SIO and other vessels

   **EM124:** a new site southwest of San Clemente Island developed in order to reduce transit time compared to an EM122/124 site used previously (see SR2101 SAT report for details)



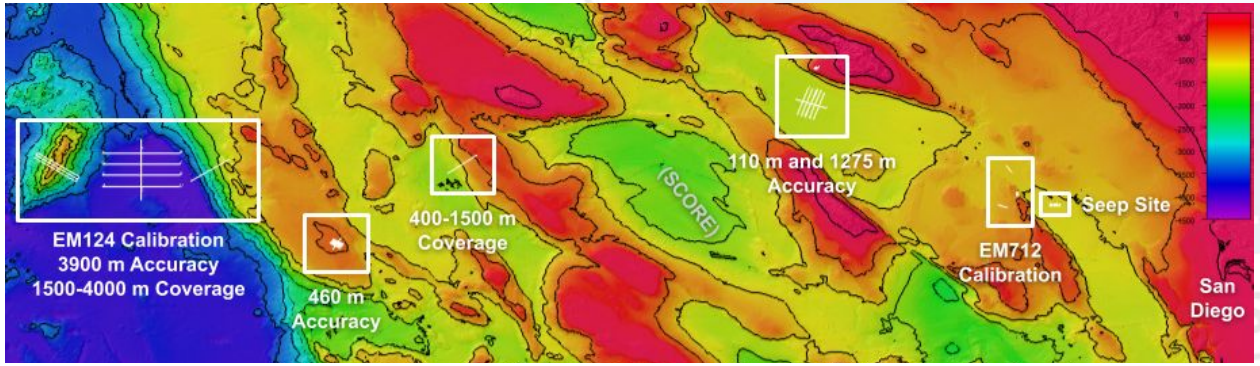



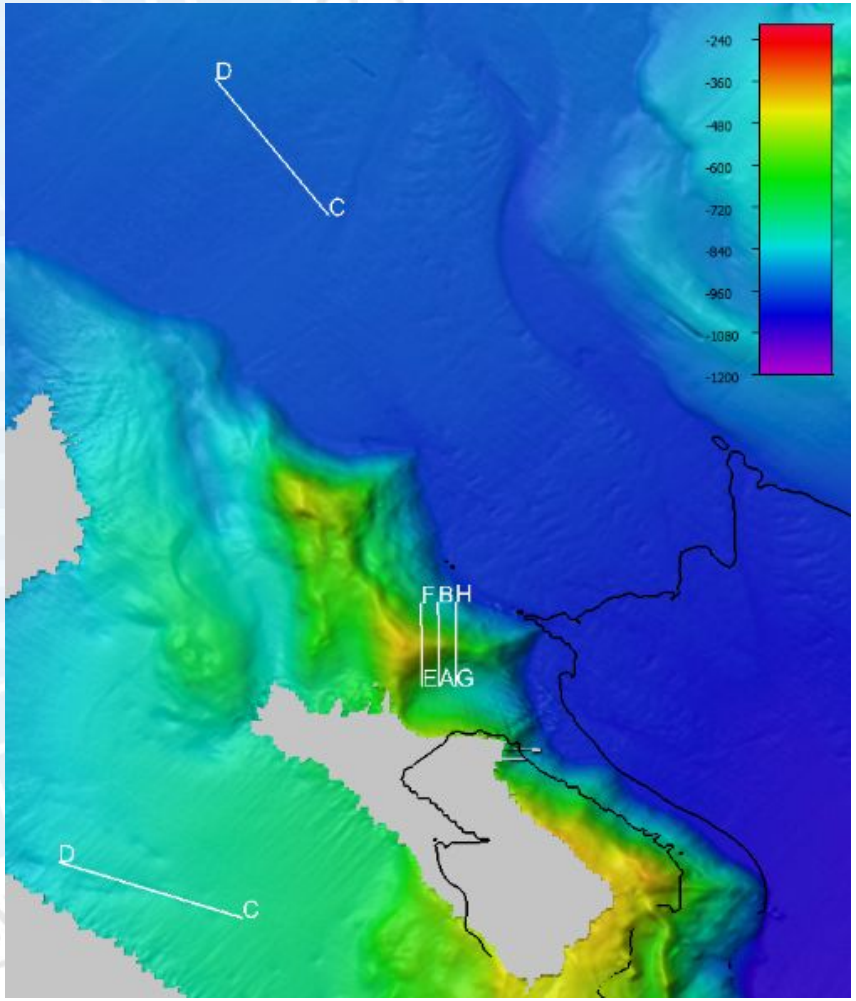
# EM712 Calibration **Planning**

1. EM712 calibration was conducted at a site used successfully for the Revelle EM712, Sikuliaq EM710, and Sally Ride EM712 off San Diego (see SR2101 SAT report for details); the 'Deep Roll' line was not used but is included here for reference

| | Waypoint | Decimal Degrees | | Degrees Decimal Minutes | | | |
|---|---|---|---|---|---|---|---|
| | | Lat. | Lon. | Lat. Deg. | Lat. Min. | Lon. Deg. | Lon. Min. |
| Pitch | A | 32.932876 | -117.902559 | 32 | 55.973 | -117 | 54.154 |
| | B | 32.946406 | -117.902697 | 32 | 56.784 | -117 | 54.162 |
| Roll (calib., south) | C | 32.895486 | -117.934882 | 32 | 53.729 | -117 | 56.093 |
| | D | 32.904512 | -117.965120 | 32 | 54.271 | -117 | 57.907 |
| Heading 1 | E | 32.932856 | -117.905367 | 32 | 55.971 | -117 | 54.322 |
| | F | 32.946385 | -117.905505 | 32 | 56.783 | -117 | 54.330 |
| Heading 2 | G | 32.932897 | -117.899752 | 32 | 55.974 | -117 | 53.985 |
| | H | 32.946426 | -117.899889 | 32 | 56.786 | -117 | 53.993 |
| Deep Roll (verif., north) | C2 | 33.008986 | -117.920674 | 33 | 0.539 | -117 | 55.240 |
| | D2 | 33.031013 | -117.939328 | 33 | 1.861 | -117 | 56.360 |

Overview of nearby test sites from SR2104



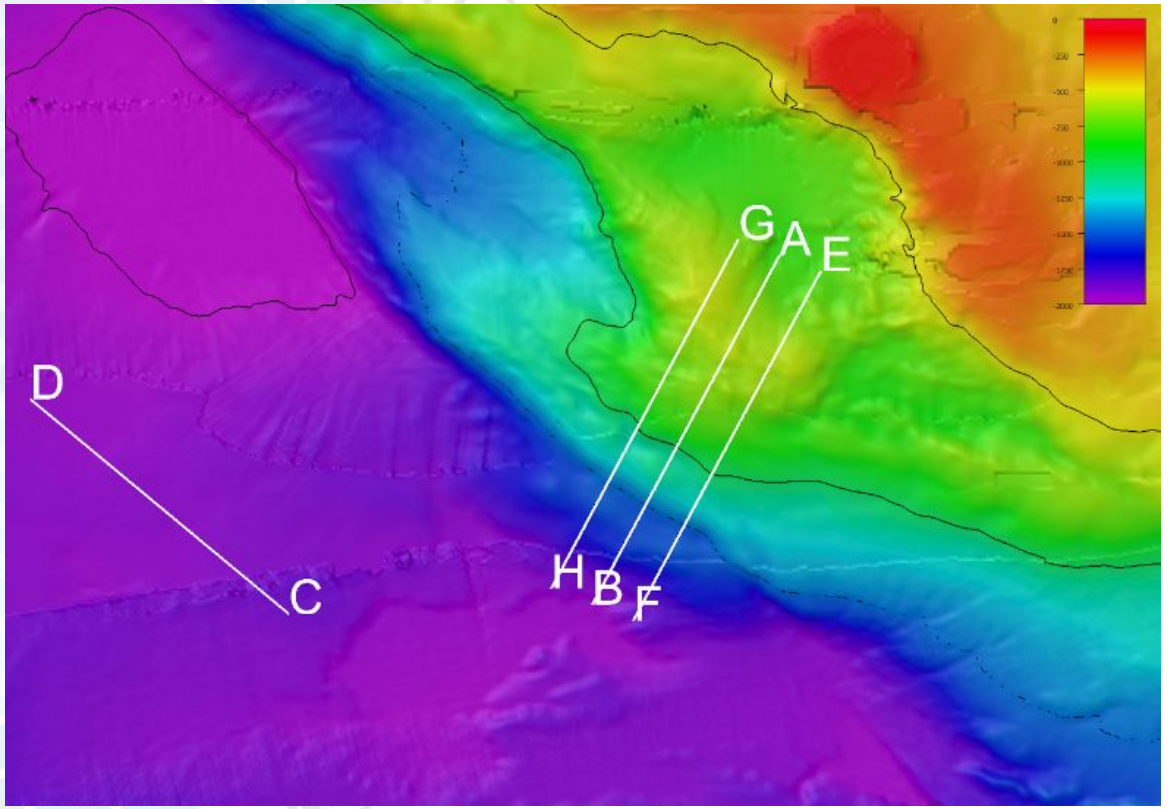



# EM124 Calibration

## Planning

1. EM124 calibration was conducted at a new site developed to minimize transit time from San Diego

| | Waypoint | Decimal Degrees | | Degrees Decimal Minutes | | | |
|---|---|---|---|---|---|---|---|
| | | Lat. | Lon. | Lat. Deg. | Lat. Min. | Lon. Deg. | Lon. Min. |
| Pitch | A | 32.609052 | -117.989941 | 32 | 36.543 | -117 | 59.397 |
| | B | 32.526944 | -118.034039 | 32 | 31.617 | -118 | 2.042 |
| Roll | C | 32.524758 | -118.105567 | 32 | 31.486 | -118 | 6.334 |
| | D | 32.575234 | -118.166450 | 32 | 34.514 | -118 | 9.987 |
| Heading 1 | E | 32.605316 | -117.980242 | 32 | 36.319 | -117 | 58.815 |
| | F | 32.523211 | -118.024346 | 32 | 31.393 | -118 | 1.461 |
| Heading 2 | G | 32.612787 | -117.999642 | 32 | 36.767 | -117 | 59.979 |
| | H | 32.530676 | -118.043732 | 32 | 31.841 | -118 | 2.624 |

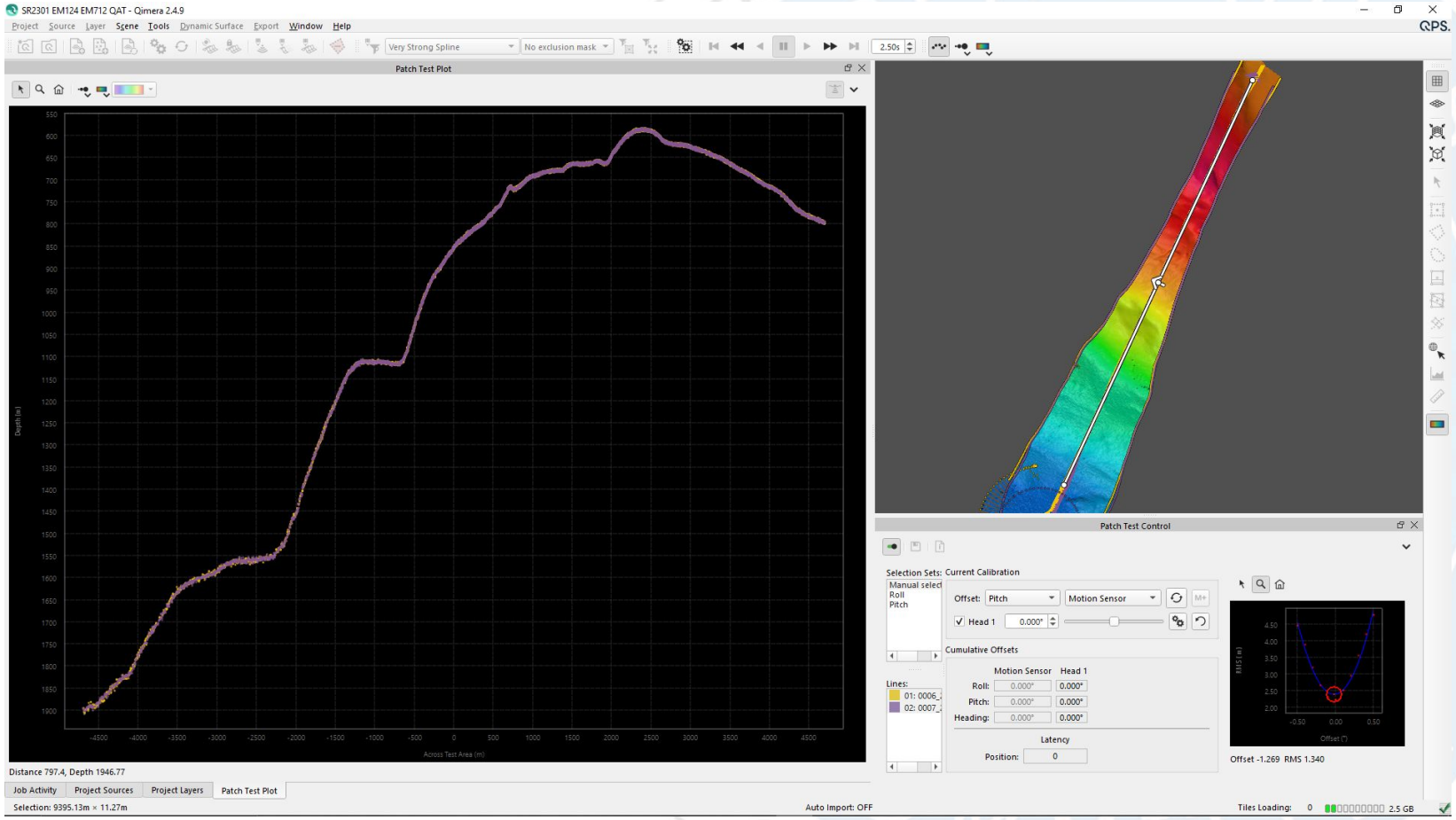


# EM124 and EM712 Calibration **Data Collection and Processing**

1. Sound speed profiles were acquired with XBTs, processed in Sound Speed Manager, and applied in SIS throughout the calibration steps for each system
2. Calibration data were examined in QPS Qimera by MAC personnel on shore; during Qimera analysis, files were processed with nearest-in-time sound speed scheduling, edited to remove outlier soundings, and then scrutinized with the patch test tool using a combination of:
   a. visual assessment and adjustment of the biases across a wide variety of data subsets
   b. 'Autosolver' method to confirm minimum RMS differences between suitable subsets
3. Results were applied by SIO personnel on board SR on April 12, 2023; these should remain unchanged until sensors are modified, the next routine assessment, or the need for additional patch testing is indicated by bathymetric artifacts

# EM124 Calibration

# Results: Pitch (Seapath)



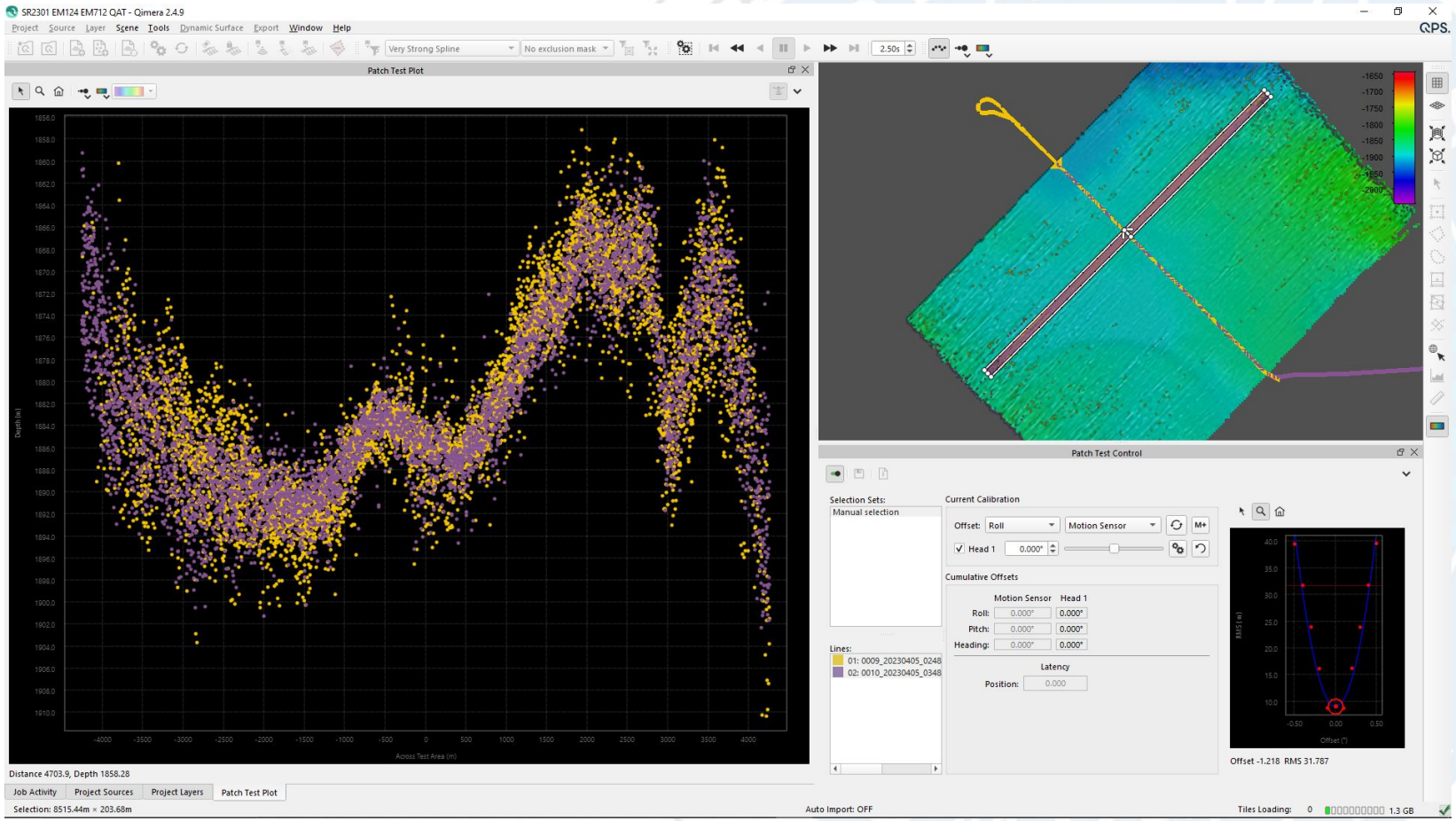

Pitch verification lines shown at left in the Qimera Patch Test Tool

Files: 6-7

1. Attitude 1 initial setting: -0.33°
2. Calibration adjustment: 0.00°
3. **Final pitch offset: -0.33° in SIS**

# EM124 Calibration

# Results: Roll (Seapath)



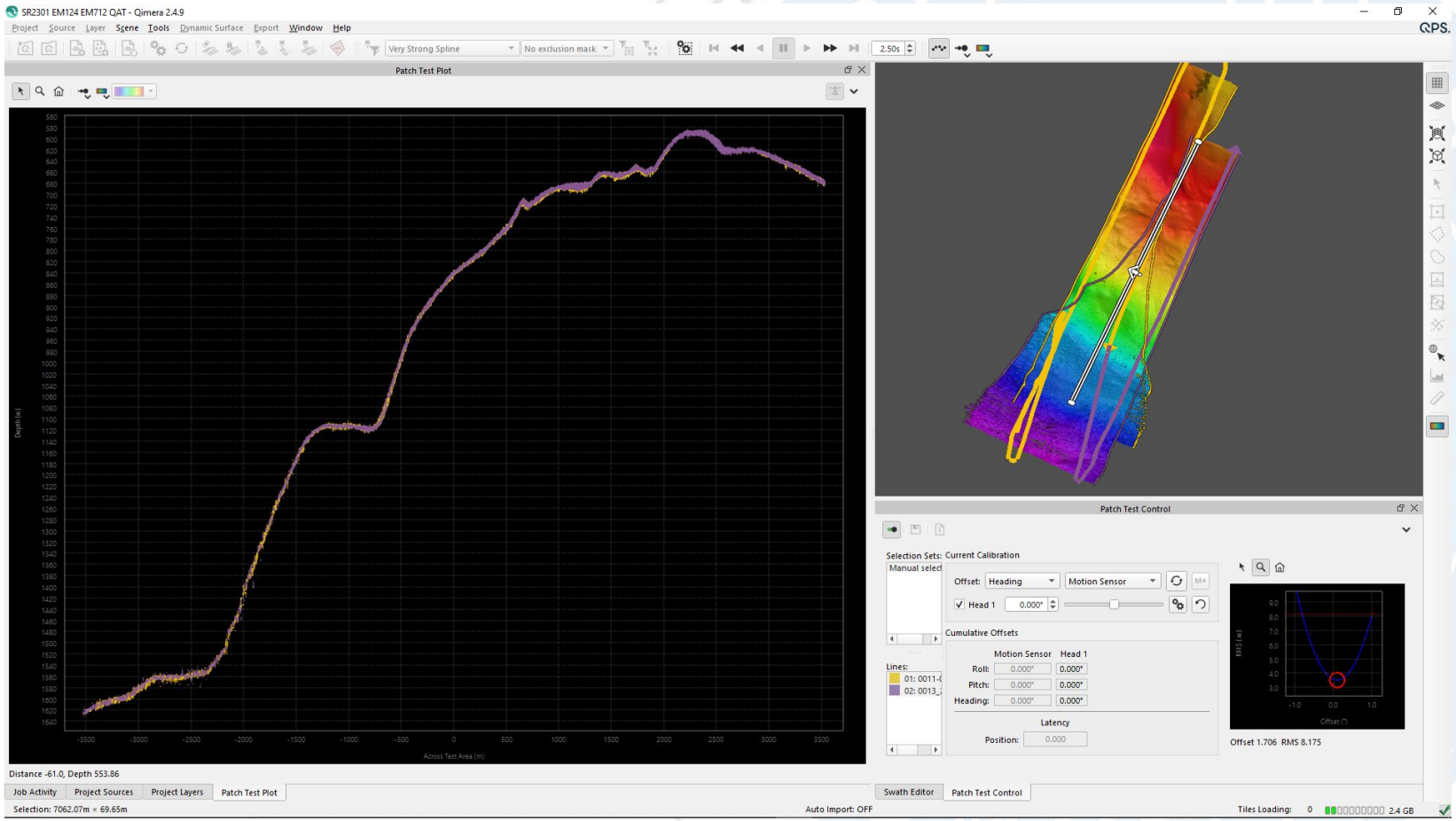

Roll verification lines shown at left in the Qimera Patch Test Tool

Files: 9-10

1. Attitude 1 initial setting: -0.175°
2. Calibration adjustment 0.00°
3. **Final roll offset: -0.175° in SIS**

# EM124 Calibration

# Results: Heading (Seapath)



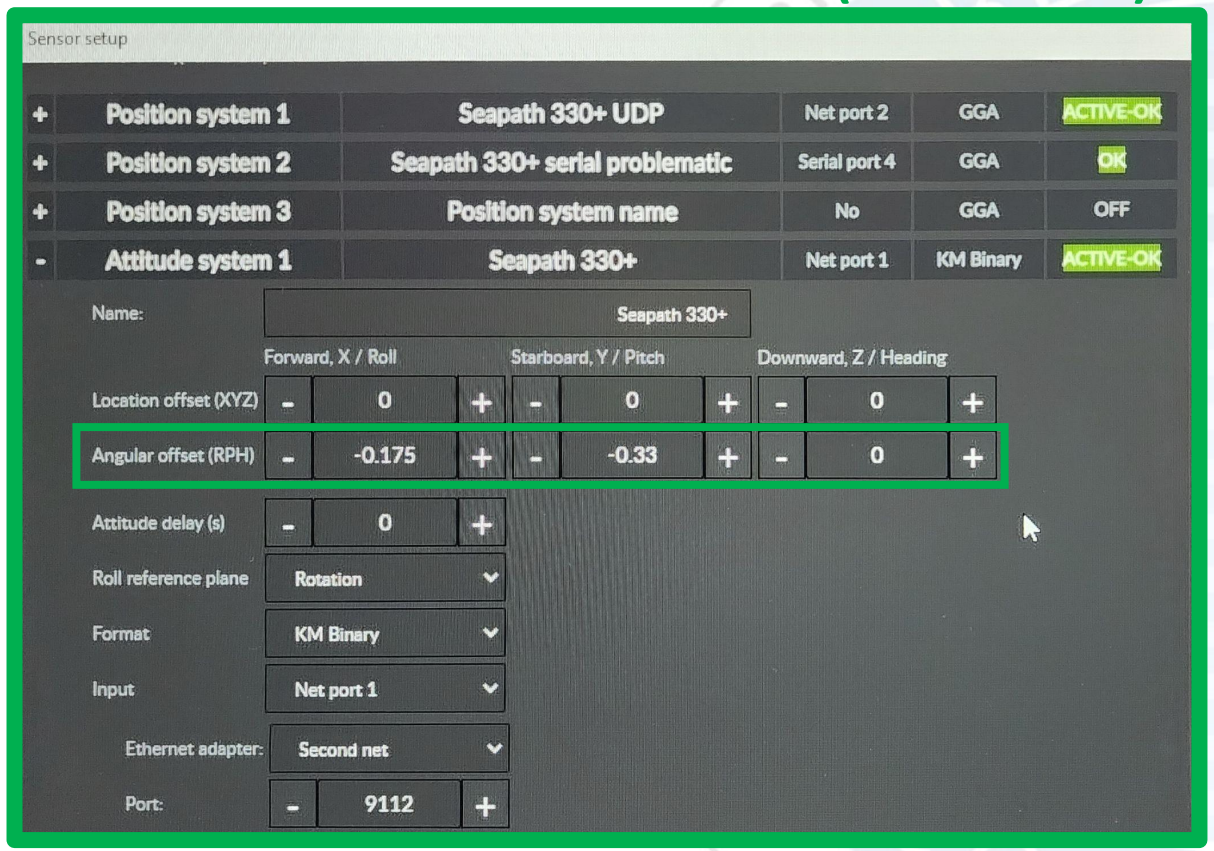

Heading calibration lines shown at left in the Qimera Patch Test Tool

Files: 58-59, 62-63

1. Attitude 1 initial setting: -0.05°
2. Calibration adjustment: +0.05°
3. **Final hdg. offset: 0.00° in SIS**

# EM124 Calibration

## POST-CALIBRATION (EM124)

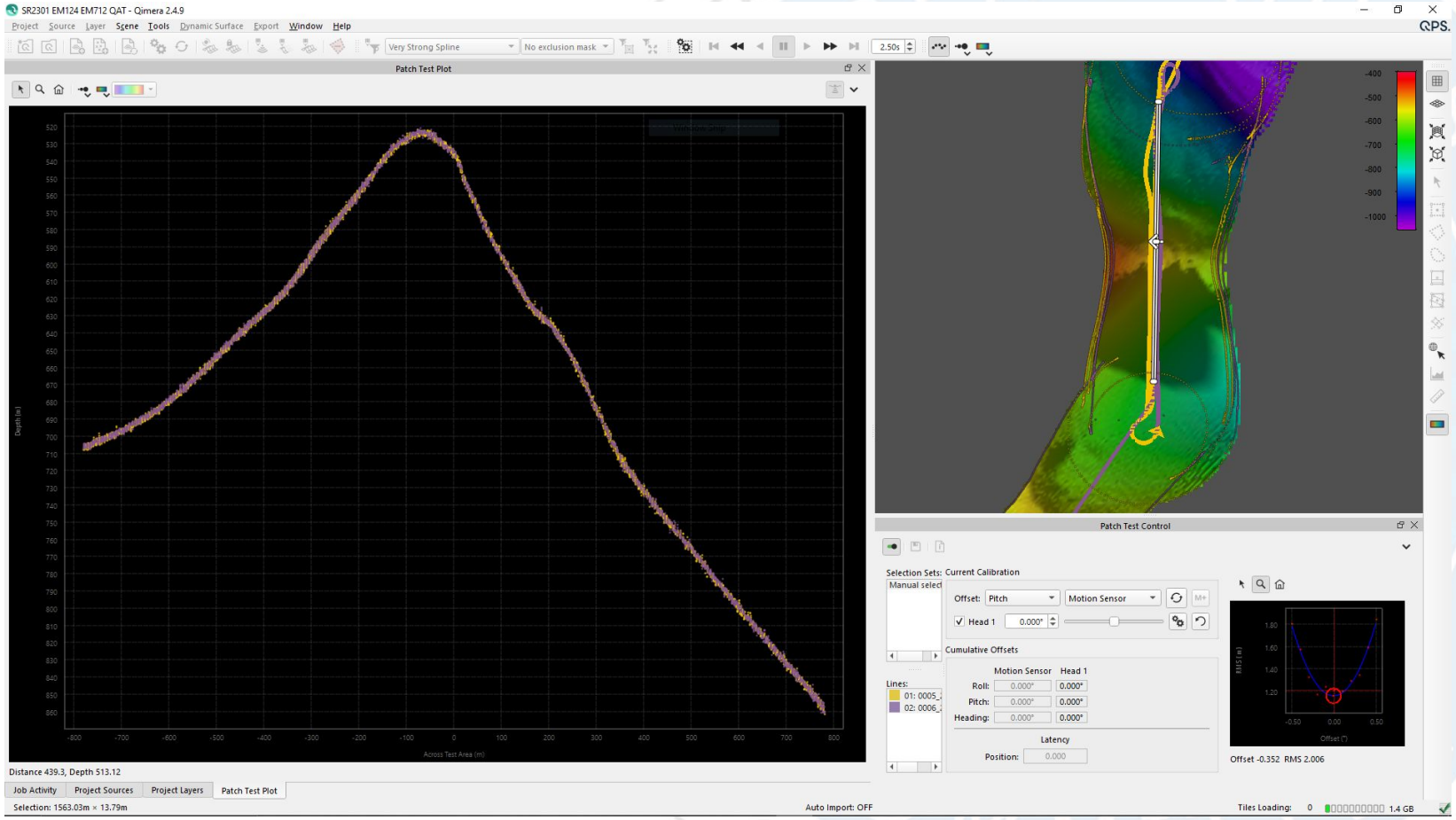



# Post-Calibration Configuration

1. The *Attitude 1* adjustments made during SR2307 are zero or very small, suggesting consistent sensor integration and stable vessel geometry
2. The *Installation Parameters: Angular Offsets* shown at left should be maintained until any modification is made to the EM124 or Seapath, or another calibration becomes necessary for other reasons

# EM712 Calibration

# Results: Pitch (Seapath)




Pitch calibration lines shown at left in the Qimera Patch Test Tool

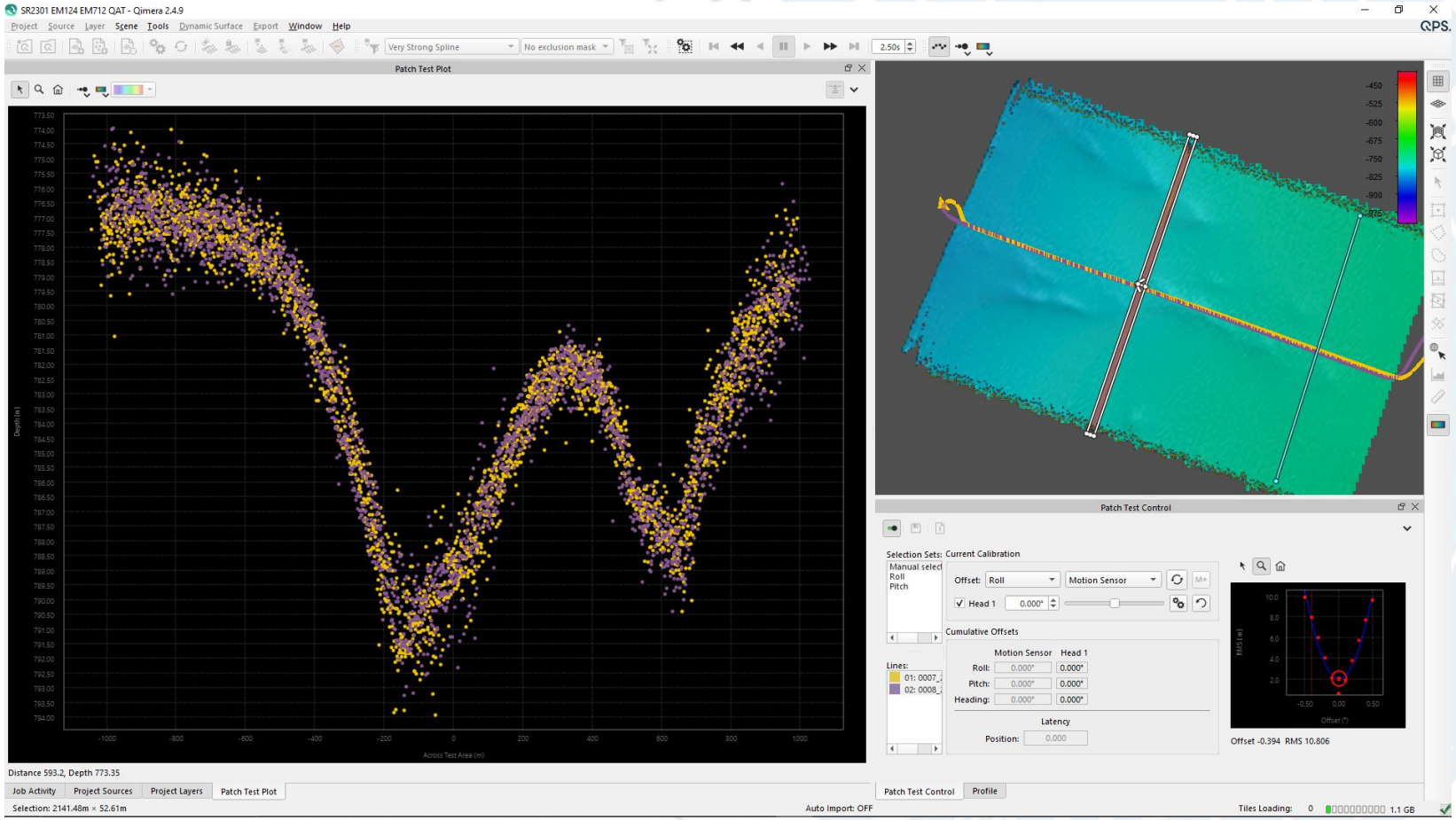
Files: 5-6

1. Attitude 1 initial setting: -0.32°
2. Calibration adjustment: 0.00°
3. **Final pitch offset: -0.32° in SIS**

Note: SR2104 SAT/QAT report v1.0 has a typo for EM712 pitch calibration on page 27 (the result is -0.32, the sum of all adjustments listed on the page, not +0.32 as reported on the last line); this typo is fixed in SR2104 report v1.1, available on the MAC website

# EM712 Calibration

# Results: Roll (Seapath)



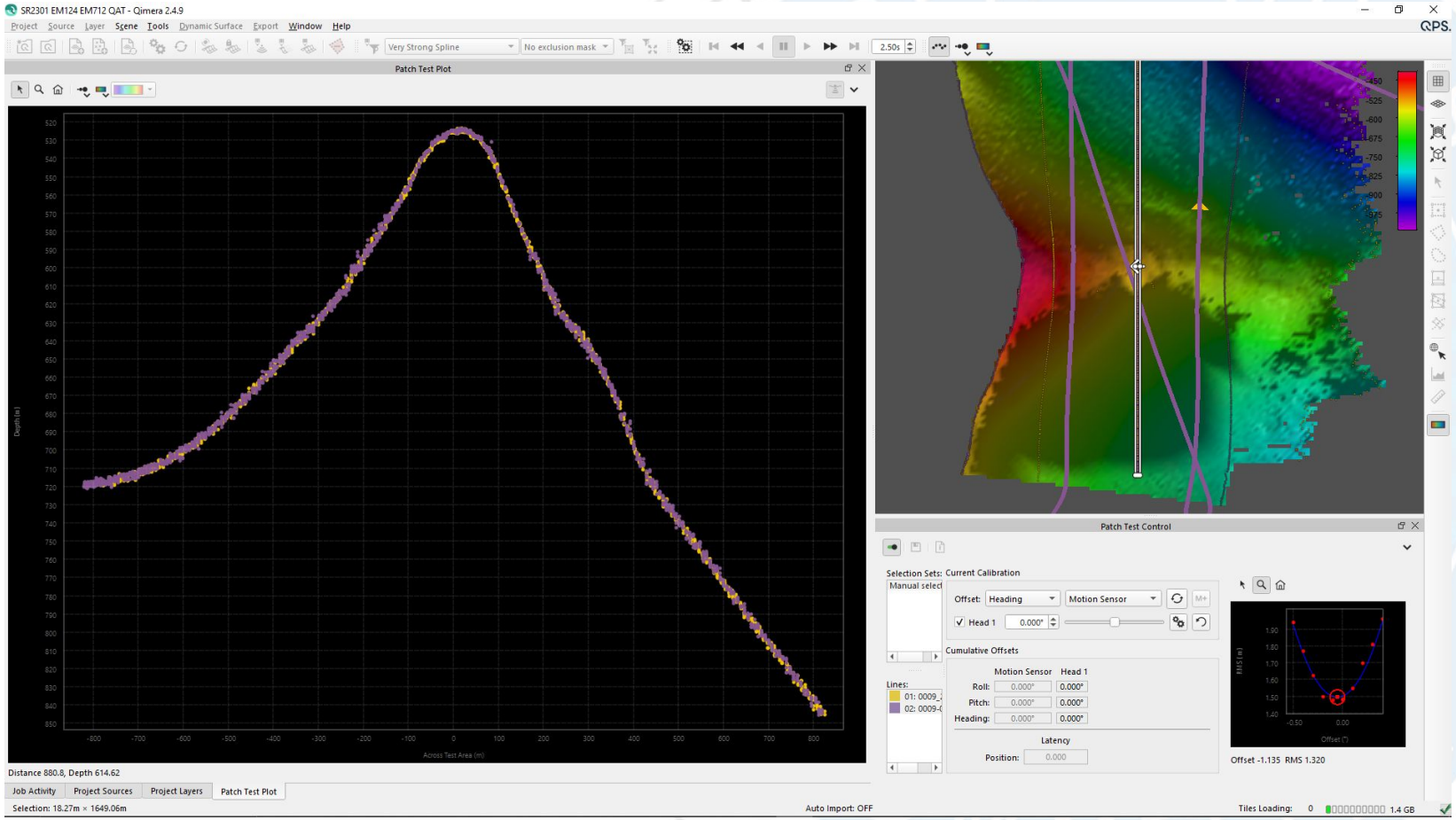

Roll verification lines shown at left in the Qimera Patch Test Tool

Files: 7-8

1. Attitude 1 initial setting: -0.11°
2. Calibration adjustment: 0.00°
3. **Final roll offset: -0.11° in SIS**

# EM712 Calibration

# Results: Heading (Seapath)



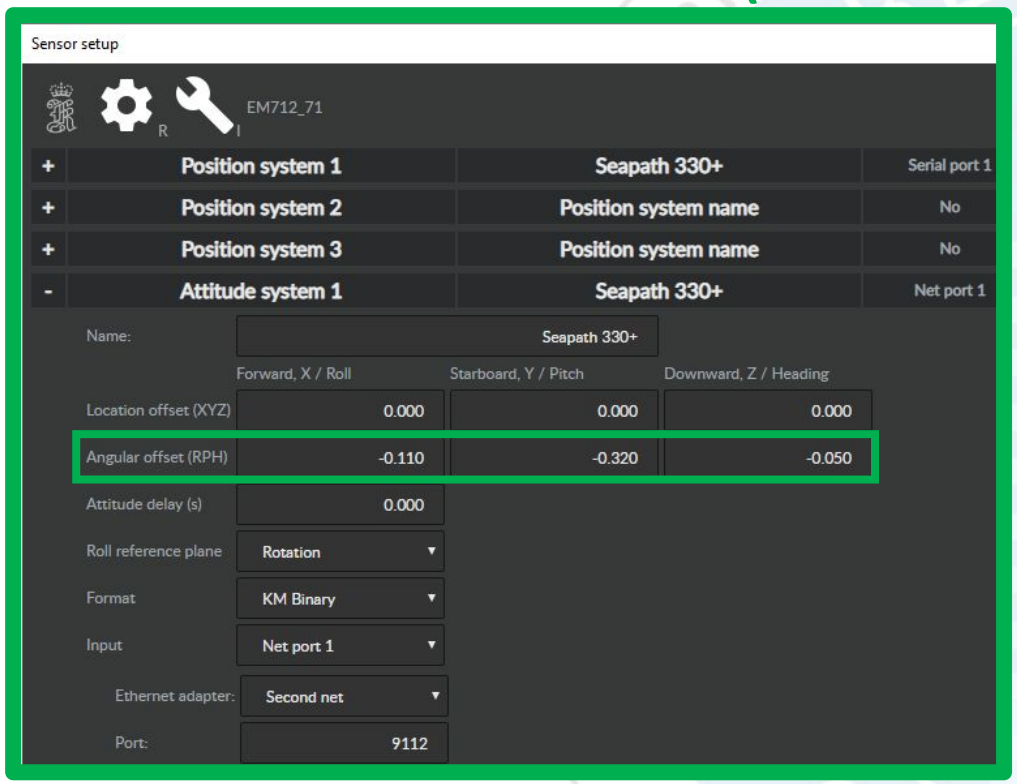

Heading calibration lines shown at left in the Qimera Patch Test Tool

Files: 9-10

1. Attitude 1 initial setting: -0.05°
2. Calibration adjustment: 0.00°
3. **Final hdg. offset: -0.05° in SIS**

# EM712 Calibration

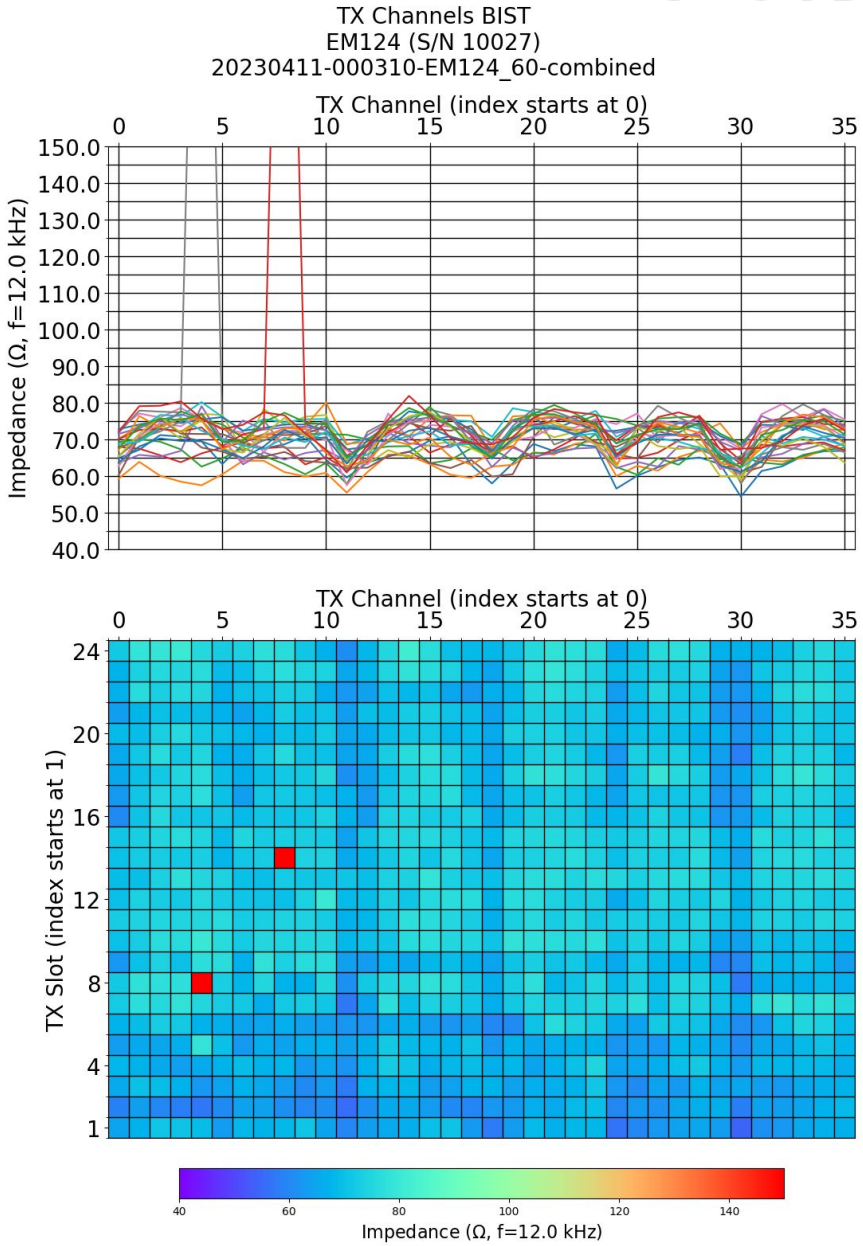
## POST-CALIBRATION (EM712)




# Post-Calibration Configuration

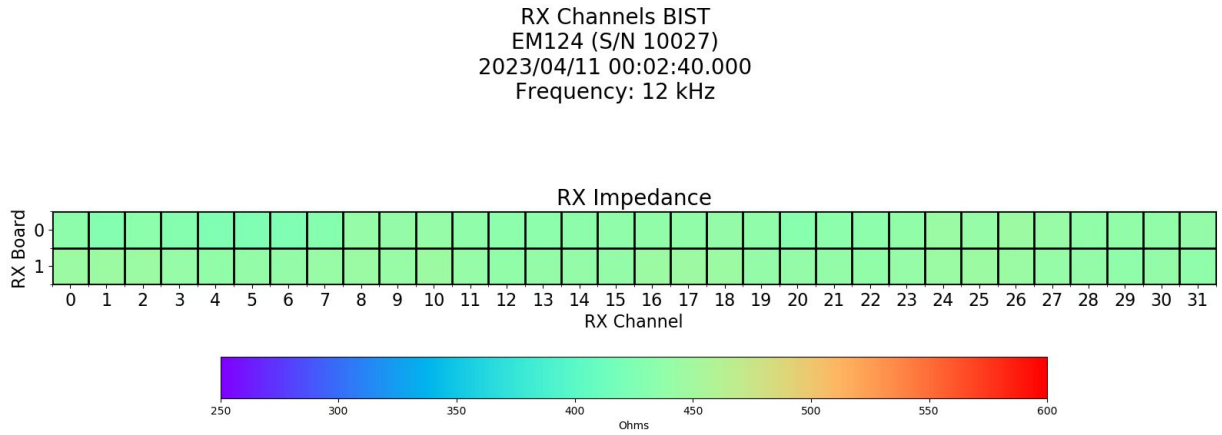
1. No *Attitude 1* adjustments were made for the EM712 during SR2307, suggesting consistent sensor integration and stable vessel geometry
2. The *Installation Parameters: Angular Offsets* shown at left should be maintained until any modification is made to the EM712 or Seapath, or another calibration becomes necessary for other reasons

# EM124 Hardware Health




# TX/RX Channels

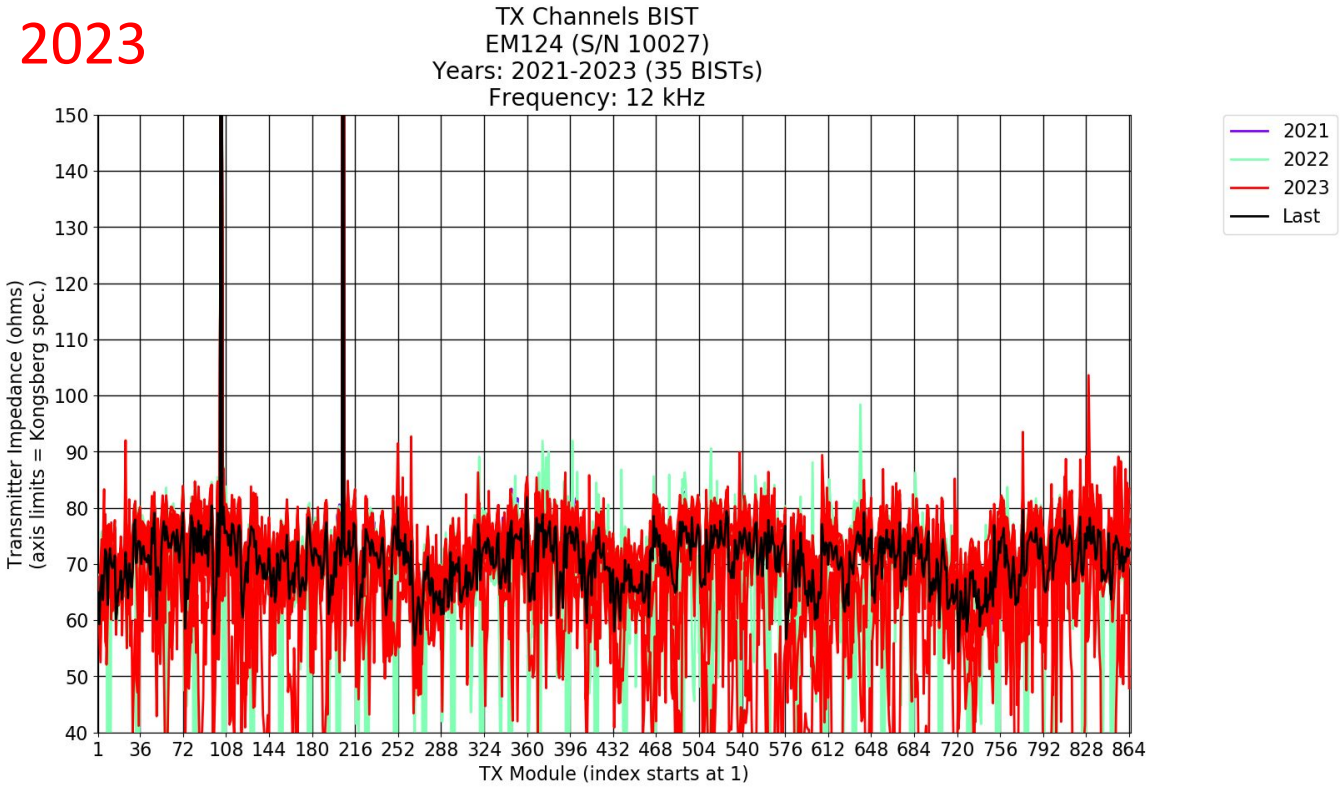
- EM124 Built-In Self-Tests (BISTs) have been collected routinely since the HAT and SAT portions of SR2104, including TX and RX Channels data that are useful as proxies for hardware health
- The color scale on each plot is based on the acceptable impedance range to pass a BIST, as defined by Kongsberg
- All but two EM124 TX elements appear to be within factory limits; the BIST history indicates these failures began appearing intermittently on 2022/08/27 and 2023/01/11
- While these are not a replacement for direct impedance tests, TX and RX Channels BISTs should be performed routinely (e.g., before and after each mapping mission) to monitor for channel failures and general shifts over time



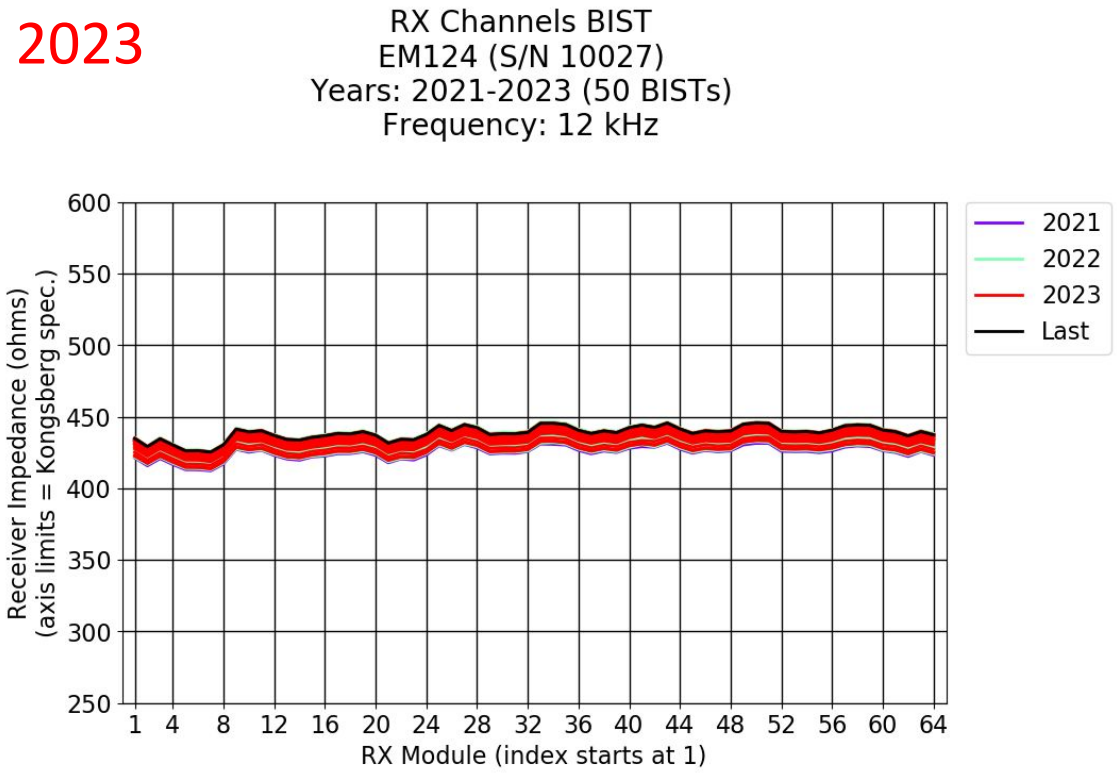
# EM124 Hardware Health

## TX/RX Channels History

2023



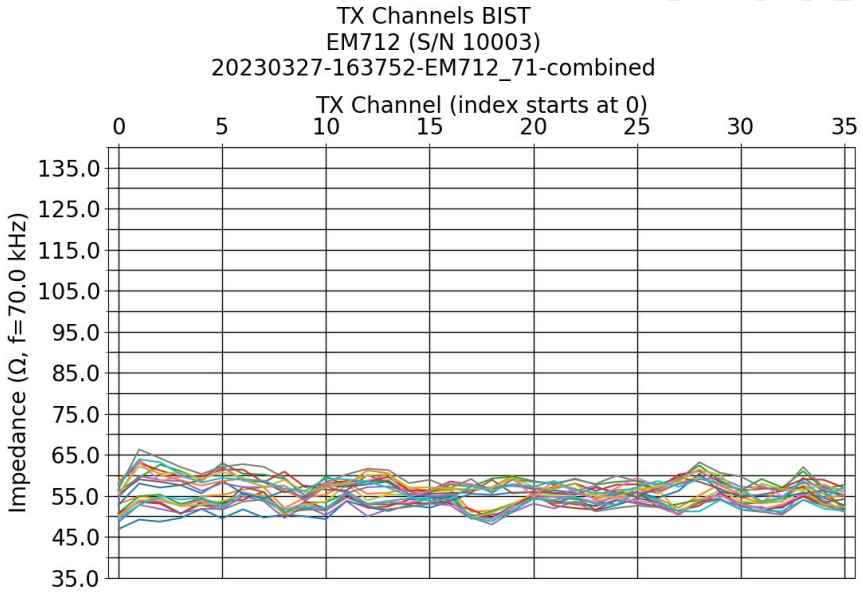

2023

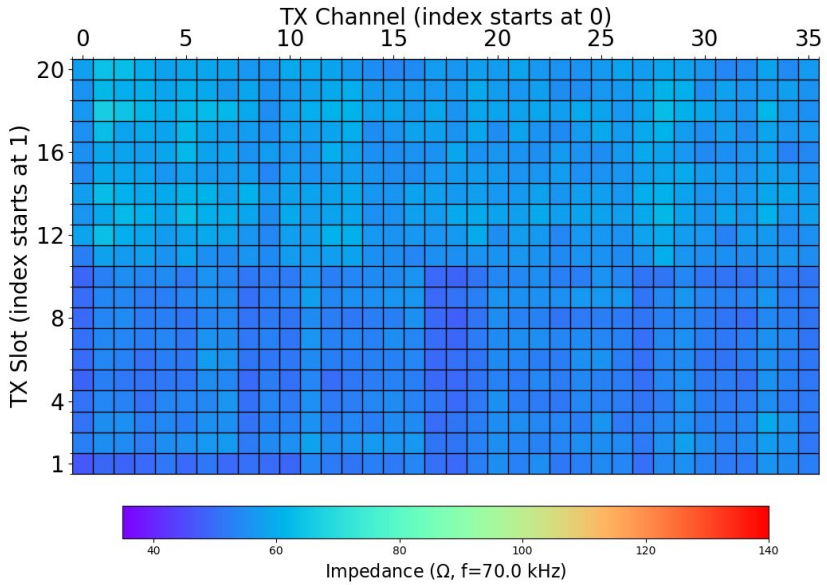


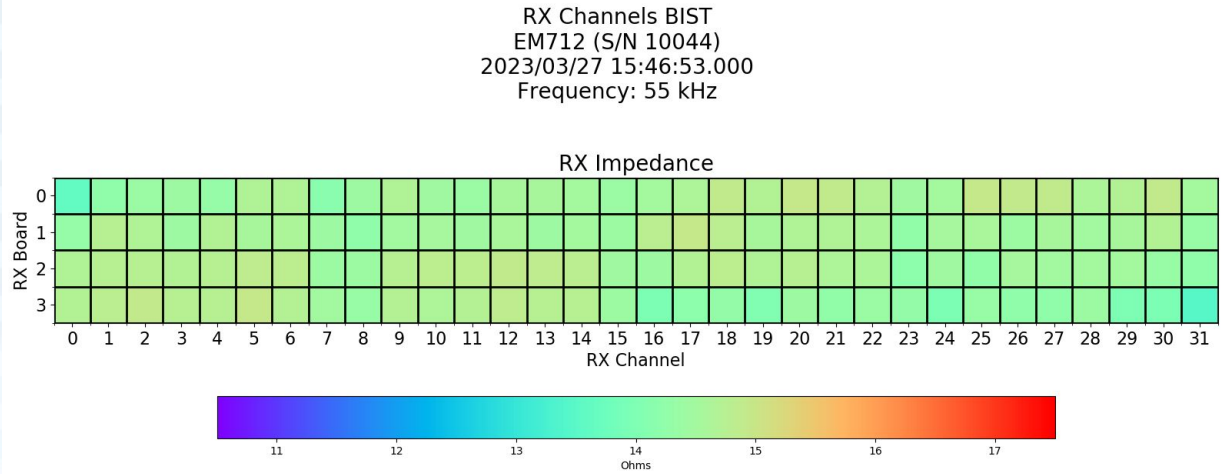
# EM712 Hardware Health

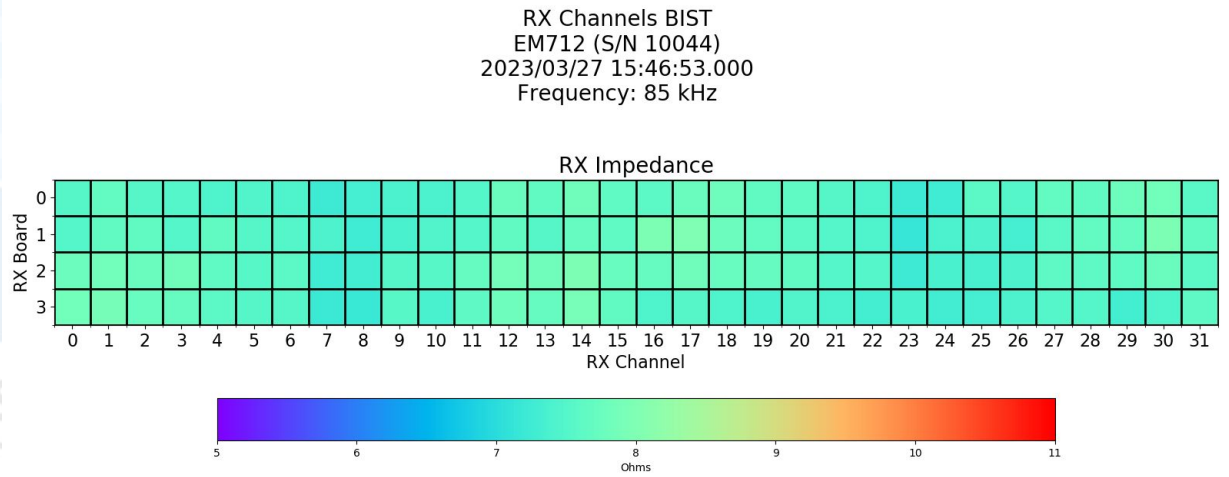
## TX/RX Channels

- EM712 Built-In Self-Tests (BISTs) have been collected routinely since the HAT and SAT portions of SR1601, including TX and RX Channels data that are useful as proxies for hardware health
- All EM712 TX/RX elements appear to be within factory limits



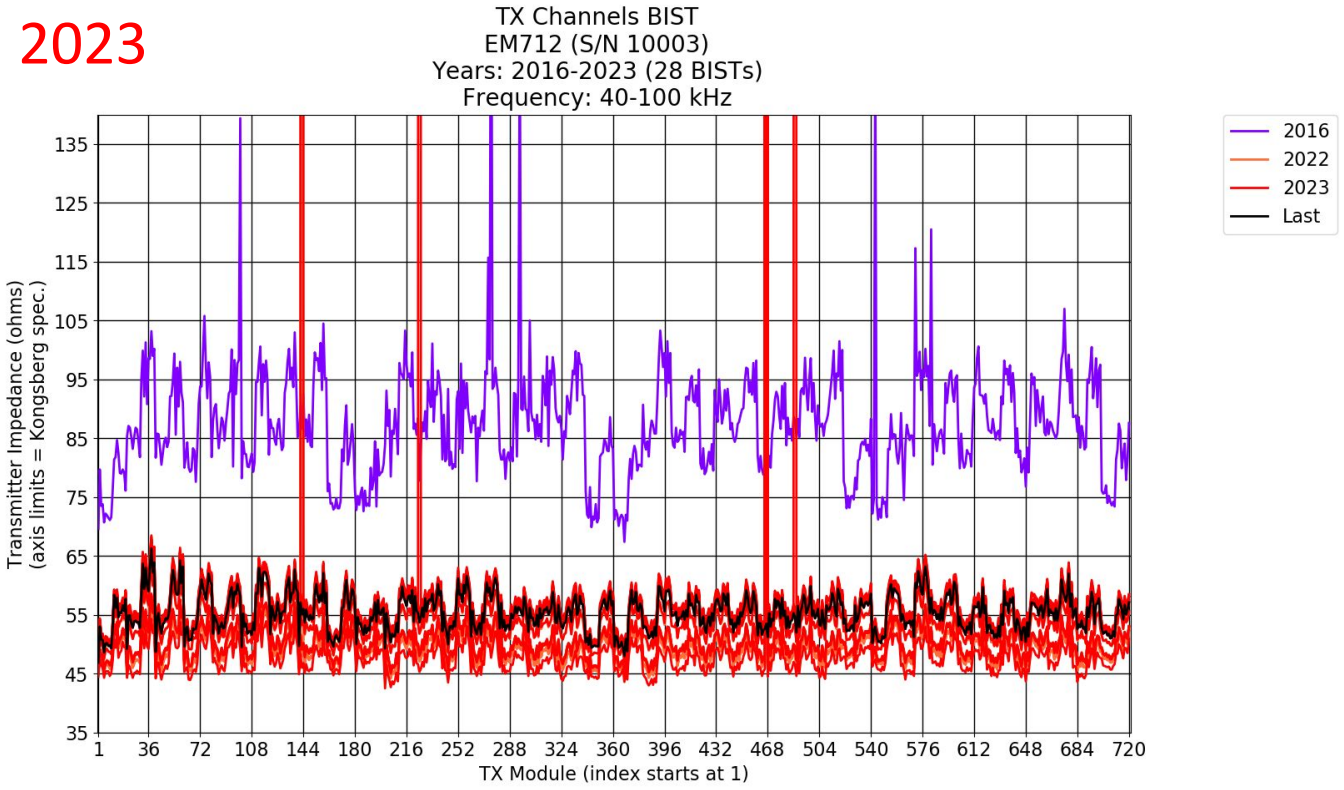



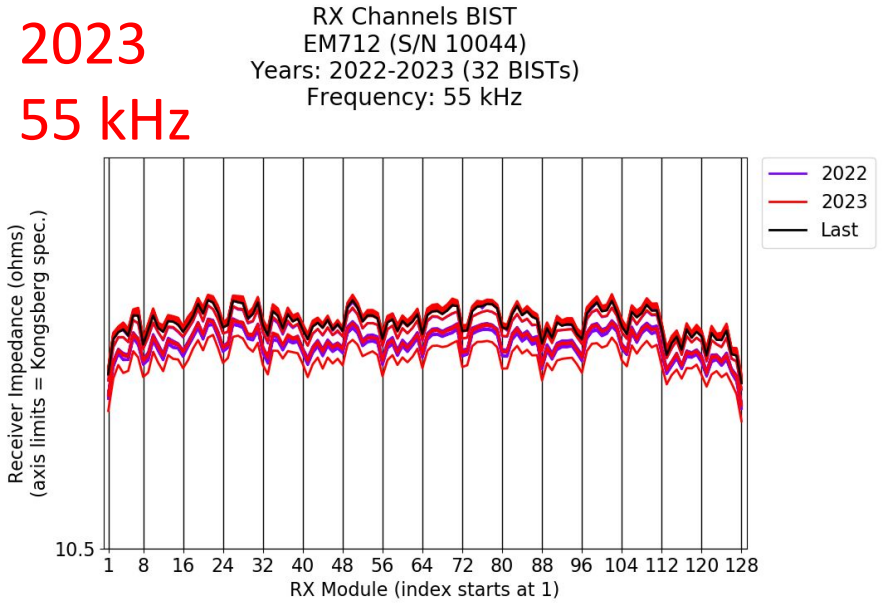
# EM712 Hardware Health

# TX/RX Channels History

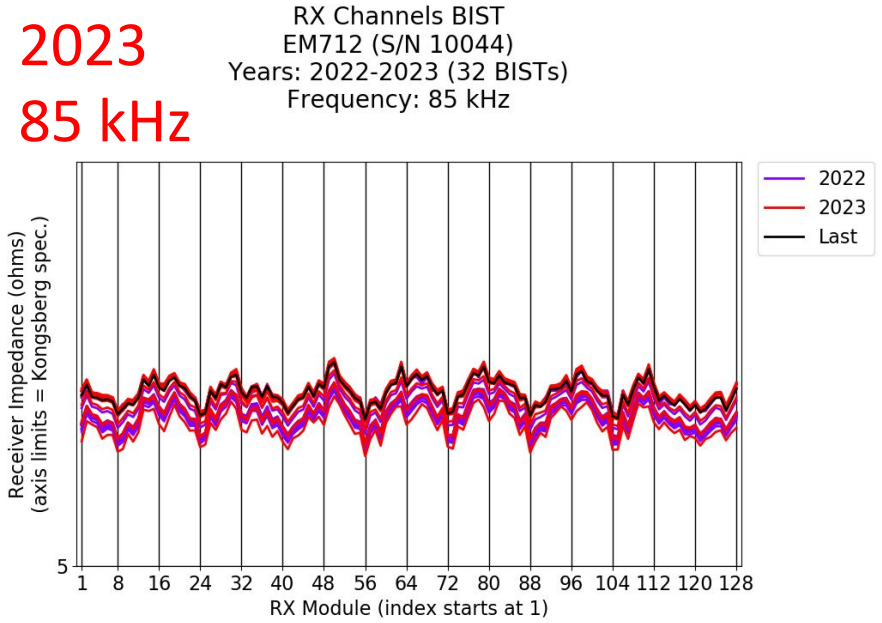
2023




2023
55 kHz




2023
85 kHz

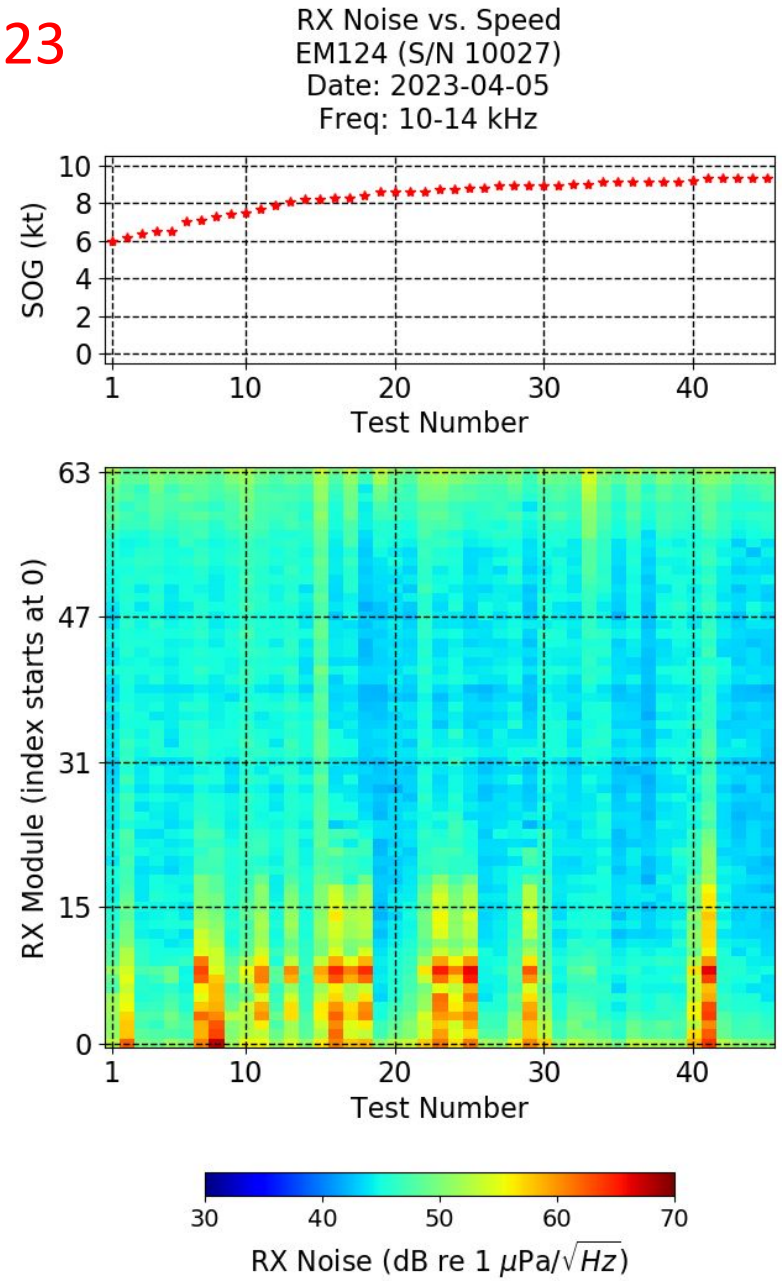



The cause of the general downward shift and flattening of TX Channels results between 2016 and 2022+ is not known; no BISTs from 2017-2021 were included, though the 2022-23 results appear stable and within spec.

A few RX Channels BISTs from 2016 onward was included, but did not parse correctly in the BIST Plotter; all recent RX Channels data appear within spec.

# RX Noise BIST Assessment

2023




# EM124 Noise Level vs. Speed

Major limitations of multibeam performance can stem from elevated noise levels due to hull design, engines and other machinery, sea state, biofouling, electrical interference, etc.

To characterize the vessel's noise environment as perceived by the EM systems, a series of continuous RX Noise Level Built-In Self-Tests (BISTs) were recorded while slowly accelerating over the range of 6-10 kts (typical mapping speeds)

EM124 RX Noise Level versus speed on April 5, 2023 is shown at left

The vertical stripes and high-amplitude (red) samples are likely caused by swell impacting the hull during the RX noise test cycle; these illustrate the broadband noise perceived in elevated sea state but do not represent typical machinery or flow noise

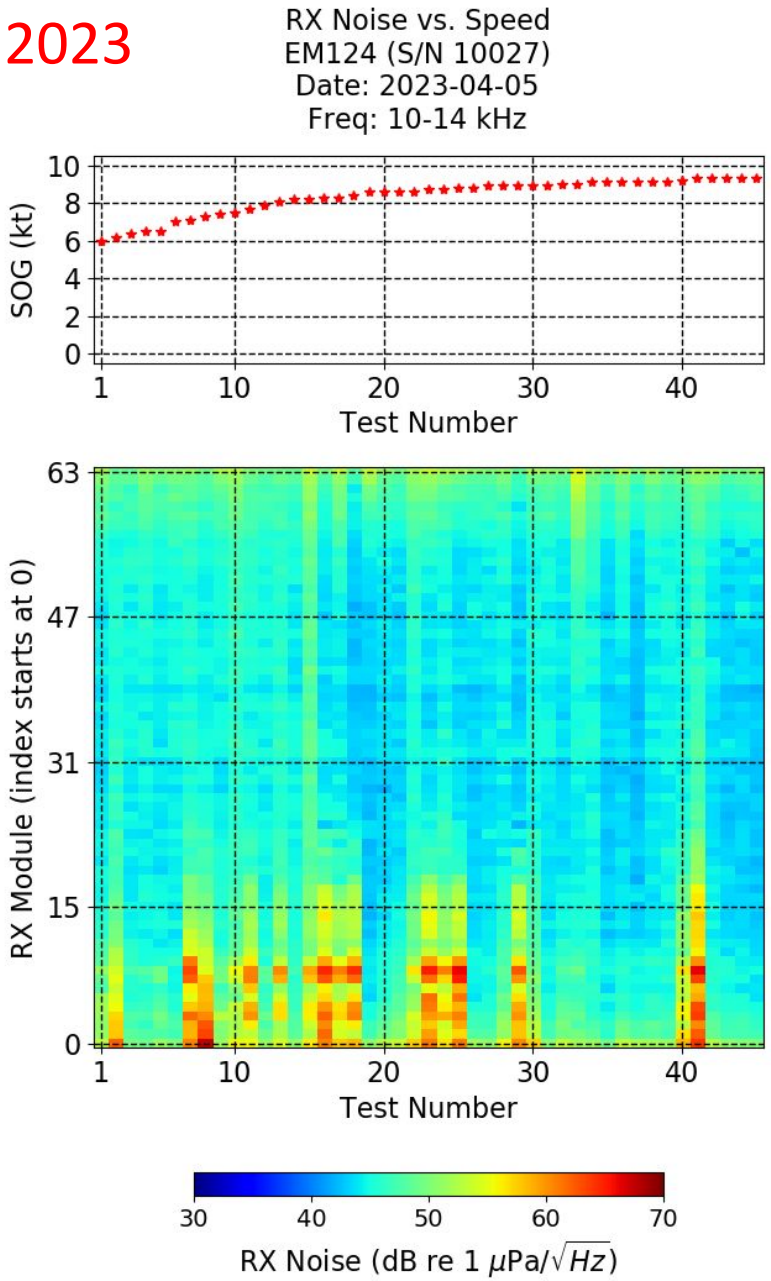
EM712 BIST logging failed and no EM712 RX Noise tests are available for SR2307; similarly, no EM712 BISTs were available during SR2104 due to technical issues

The MAC is available to plot EM712 BISTs once logging is restored

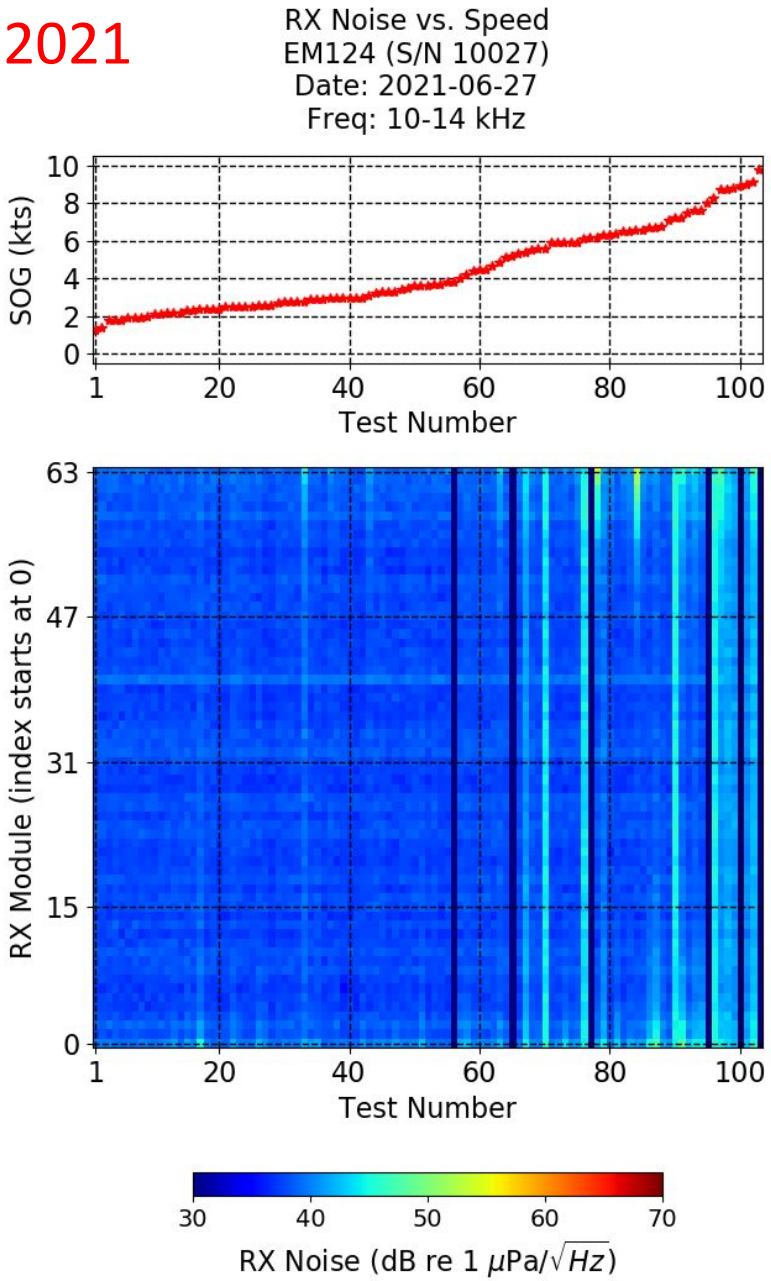
# RX Noise BIST Assessment

## EM124 Noise vs. Speed History

2023




2021




Comparison to 2021 (SR2104) EM124 RX Noise testing shows a significant increase in noise levels at speeds of 6-9.5 kts; it is unknown whether this trend continues at lower speeds

The cause of these higher noise levels should be investigated and addressed, as they will negatively impact swath coverage and accuracy (and may worsen over time)

Common causes include biofouling on the hull and arrays, as well as machinery modifications between tests

The MAC is available to process additional RX Noise testing, especially after EM712 BIST continuous logging is restored


photo: SIO