R/V *Roger Revelle*

EM712 & EM124
Multibeam Echosounder
Calibration Report
February 4-19, 2023
RR2301

Multibeam Advisory Committee
Report prepared by:
Kevin W. Jerram
Paul D. Johnson
Vicki Ferrini

Supported under NSF Grant No. 1933720

photo: Erik Jepsen, UCSD Publications

Executive Summary

1. R/V *Roger Revelle* (RR) underwent routine calibrations of the ship's multibeam echosounders during an extended transit/cruise between Punta Arenas, Chile, and Cape Town, South Africa in February 2023; the MAC provided remote support for planning and data analysis leading up to and throughout the calibration

2. Planning followed the standard MAC SAT/QAT checklist, focusing on calibrations at suitable sites within reasonable deviations along the transit route; these were completed in two phases with initial EM124 testing near Puntarenas, followed by EM124 re-calibration and EM712 calibration at suitable sites off Cape Town

3. The initial EM124 calibration was completed with a TX array pitch error inadvertently held over from the 2020 EM124 and EM712 SAT; this was corrected for the second calibration, resulting in typically small adjustments

4. During the approach to the second calibration area off Cape Town, an EM712 configuration error was detected and discussed over ship-to-ship calls between the MAC (at sea on another vessel) and technicians on board the *Revelle*; EM712 calibration was completed with the correct configuration and small results (as expected)

5. This report describes the procedures and results for calibrations ('patch tests') of the EM124 and EM712

6. The MAC thanks the *Revelle's* shipboard technicians for collecting all QAT data, noticing data quality issues with the EM712, and following up quickly with questions to ensure successful calibrations for both systems

System Geometry Review

Overview: History

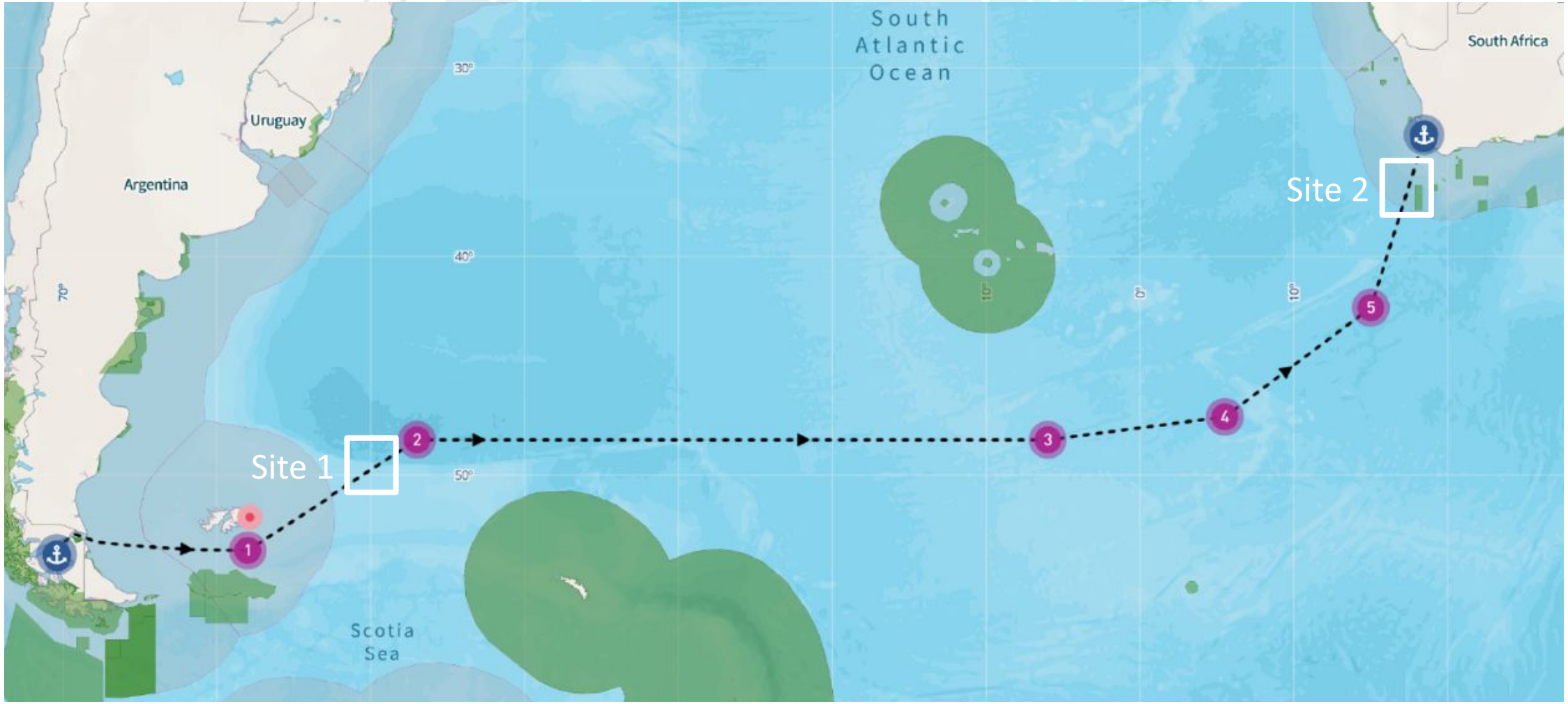
The term ‘system geometry’ means the linear and angular offsets of the primary components of the multibeam mapping systems, including the transmit arrays (TX), receive arrays (RX), GNSS antennas, and motion sensors (MRU/IMU). The following table provides an overview of the system geometry history.

See the 2020 SAT report for a full description of all mapping sensor offsets and configurations.

Date	Location	Event	References
2003	San Diego, CA	Blom survey to establish vessel reference frame and offsets of EM120 mapping system with origin on Master Reference Plate (MRP), under MRU mount then in service	Blom survey report (see RR1301 QAT)
2011	Taiwan	Re-establish 2003 reference frame and survey primary GPS antenna mount	Blom survey report (see RR1301 QAT)
2013	San Diego, CA	Quality assurance testing; system geometry review and calibration of EM122 for residual angular offsets with HYDRINS and Seapath MRUs	RR1301 QAT report provided by MAC
2019-20	Portland, OR and San Diego, CA	IMTEC survey to establish new reference frame with origin at starboard, aft, top corner of MRP; survey EM712 arrays, EM124 arrays, Seapath MRU, and Trimble antennas	IMTEC survey report Rev. 1 (8/24/2020)
2020-10	San Diego, CA	Sea acceptance testing; system geometry review, Seapath antenna calibration, and geometric calibrations (‘patch tests’) of EM124 and EM712 with Seapath 330+	2020 SAT report
2023-01	Chile - South Africa	EM124 and EM712 configuration reviews and calibrations; EM124 TX array pitch corrected from +0.519° (typo) to +0.052° (IMTEC report, 2020) ahead of calibration off Cape Town	This document

Planning Overview

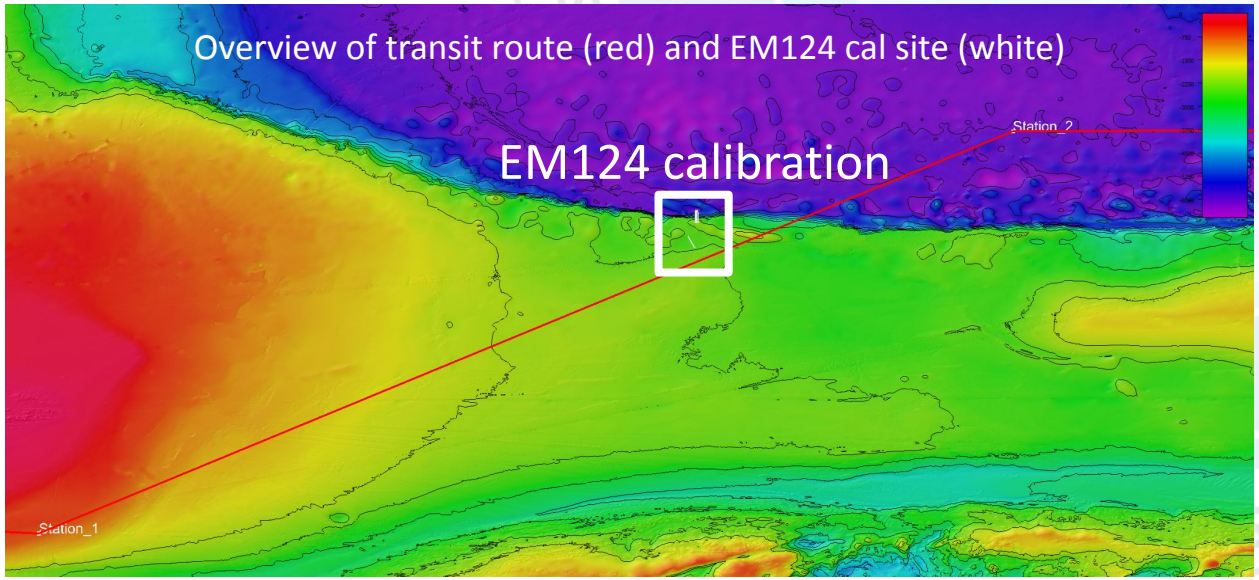
1. Calibrations were planned at two sites along the transit route between Punta Arenas and Cape Town
2. Three calibration plans were developed and proven at these two sites (available for future multibeam testing)

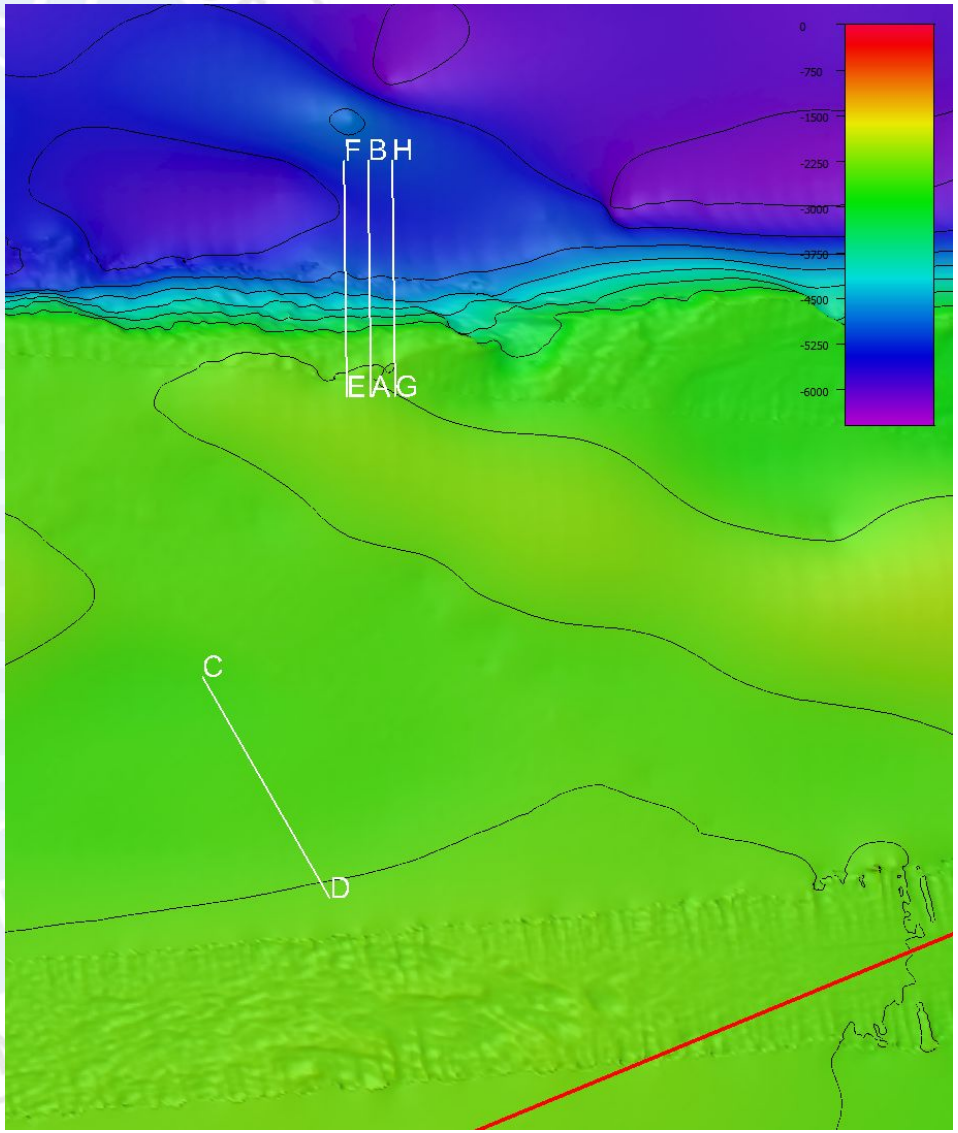


EM124 Calibration Site 1 **Planning: Chile**

1. The first EM124 calibration of RR2301 was conducted at a newly developed site intended to minimize deviation from the transit route: [Atlantic_EM124_Punta_Arenas_Chile]

	Waypoint	Decimal Degrees		Degrees Decimal Minutes			
		Lat.	Lon.	Lat. Deg.	Lat. Min.	Lon. Deg.	Lon. Min.
Pitch	A	-49.517460	-50.569409	-49	31.048	-50	34.165
	B	-49.382540	-50.570589	-49	22.952	-50	34.235
Roll	C	-49.676719	-50.666035	-49	40.603	-50	39.962
	D	-49.803269	-50.593871	-49	48.196	-50	35.632
Heading 1	E	-49.517510	-50.583224	-49	31.051	-50	34.993
	F	-49.382590	-50.584366	-49	22.955	-50	35.062
Heading 2	G	-49.517407	-50.555594	-49	31.044	-50	33.336
	H	-49.382488	-50.556812	-49	22.949	-50	33.409

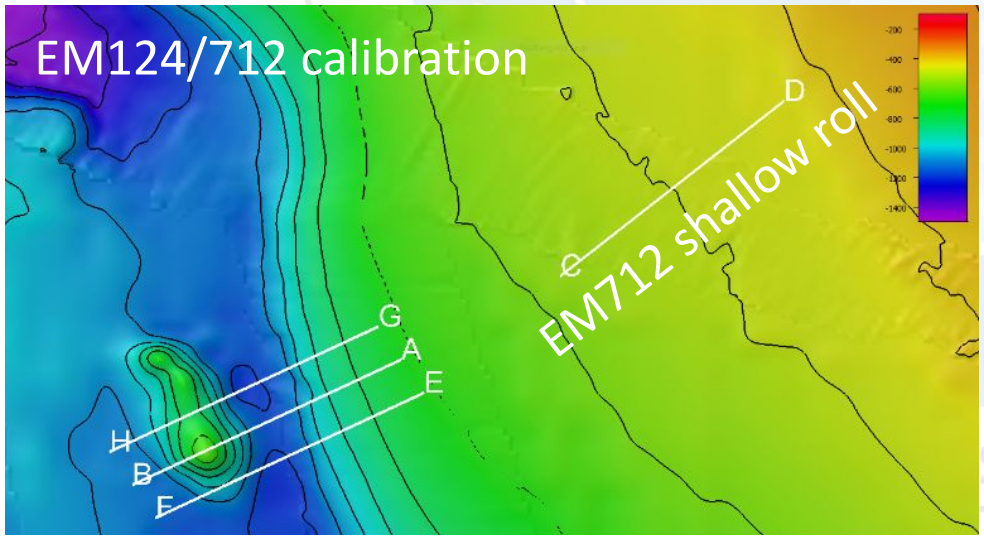


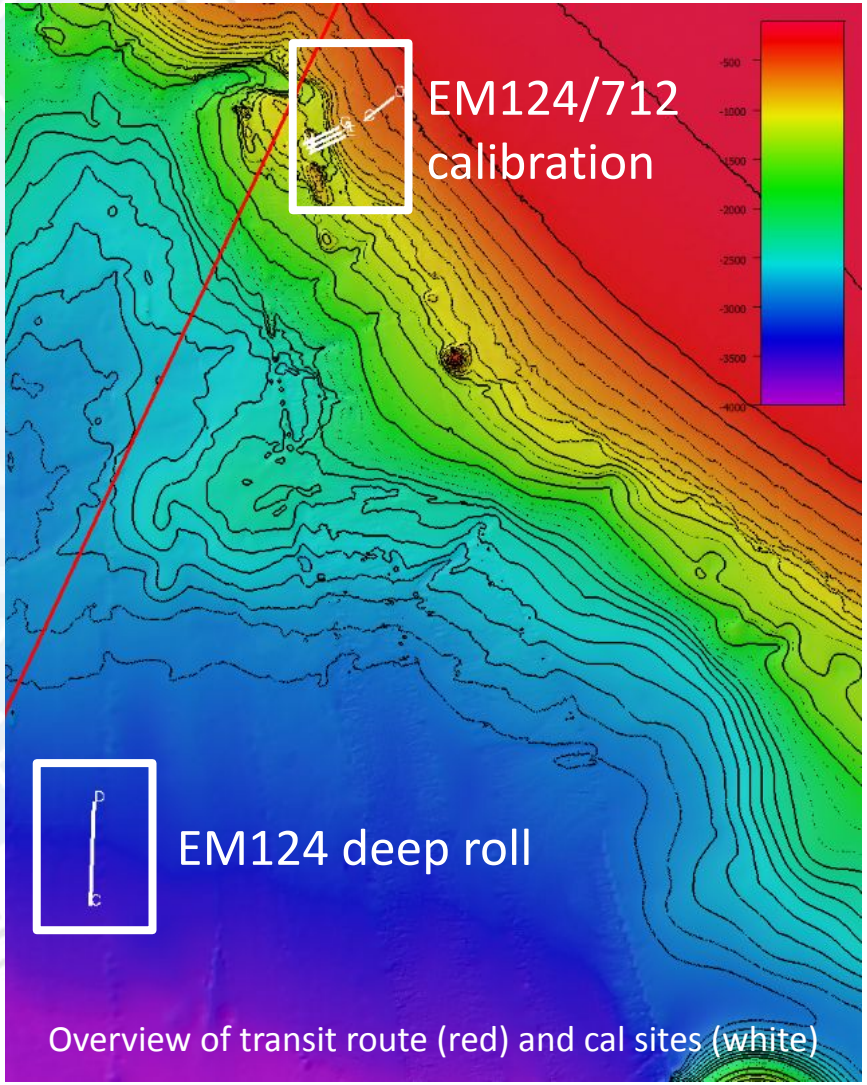


EM124 / EM712 Calibration **Planning: South Africa**

1. The second EM124 calibration and first EM712 calibration were conducted at a newly developed site along the final approach to Cape Town, using different roll calibration lines for each system: [Atlantic_EM124_Cape_Town]

	Waypoint	Decimal Degrees		Degrees Decimal Minutes			
		Lat.	Lon.	Lat. Deg.	Lat. Min.	Lon. Deg.	Lon. Min.
DEEP Roll (EM124 only)	C (DEEP)	-36.167537	18.197598	-36	10.052	18	11.856
	D (DEEP)	-36.032462	18.202394	-36	1.948	18	12.144
Pitch (EM712/124)	A	-35.156383	18.526861	-35	9.383	18	31.612
	B	-35.178612	18.479133	-35	10.717	18	28.748
Roll (EM712/124)	C	-35.141536	18.555139	-35	8.492	18	33.308
	D	-35.110460	18.594853	-35	6.628	18	35.691
Heading 1 (EM712/124)	E	-35.162261	18.530923	-35	9.736	18	31.855
	F	-35.184492	18.483192	-35	11.070	18	28.992
Heading 2 (EM712/124)	G	-35.150505	18.522799	-35	9.030	18	31.368
	H	-35.172732	18.475074	-35	10.364	18	28.504

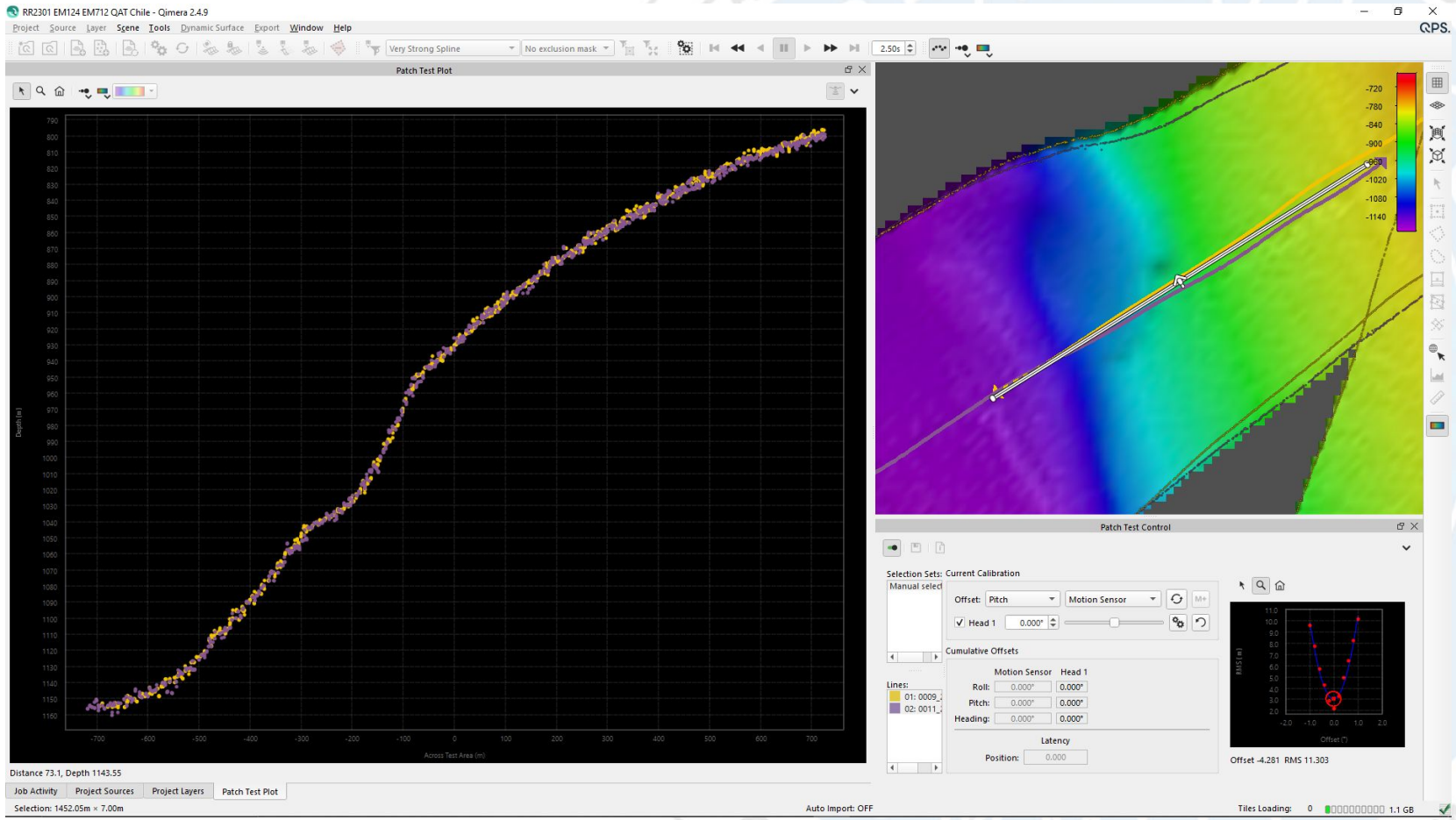




EM124 and EM712 Calibration **Data Collection and Processing**

1. Sound speed profiles were acquired, processed in Sound Speed Manager, and applied in SIS throughout data collection for each system
2. The initial EM124 calibration off Chile was conducted with an erroneous EM124 TX array pitch angle (typo from 2020 SAT); this was corrected from +0.519° to +0.052° (correct TX pitch from the 2020 IMTEC survey report) ahead of the second calibration off Cape Town, and the Attitude 1 pitch value was reset to zero for this test
3. Odd-looking initial EM712 data were forwarded by shipboard technicians to the MAC and revealed configuration errors stemming from a PU swap; the EM712 configuration was restored to the 2020 EM712 SAT state through a series of discussions prior to re-running the EM712 calibration lines with the correct offsets
4. EM124 and EM712 data were transferred in full .kmall format for processing by MAC personnel
5. During MAC analysis, files were processed with nearest-in-time sound speed scheduling, edited to remove outlier soundings, and then scrutinized with the Qimera 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
6. No latency check was performed, as this has not been an issue in the past (e.g., see 2020 SAT report) and it is not clear whether a small position latency will be detectable in deep water; no obvious position or attitude latency artifacts were present in the calibration datasets

EM124 Calibration (Cape Town) **Results: Pitch (Seapath)**

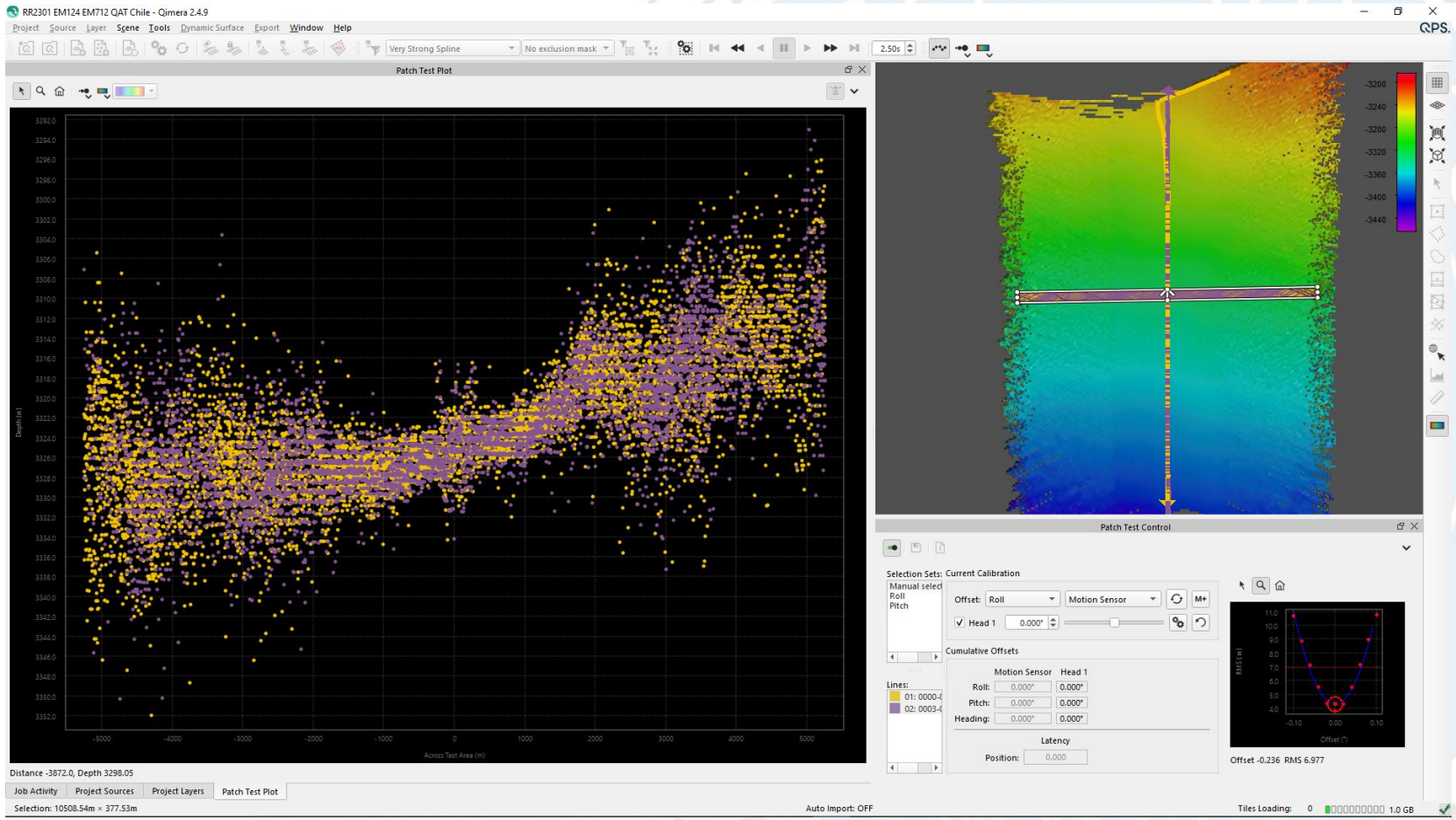


Pitch calibration lines shown at left in the Qimera Patch Test Tool

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

EM124 Calibration

Results: Roll (Seapath)

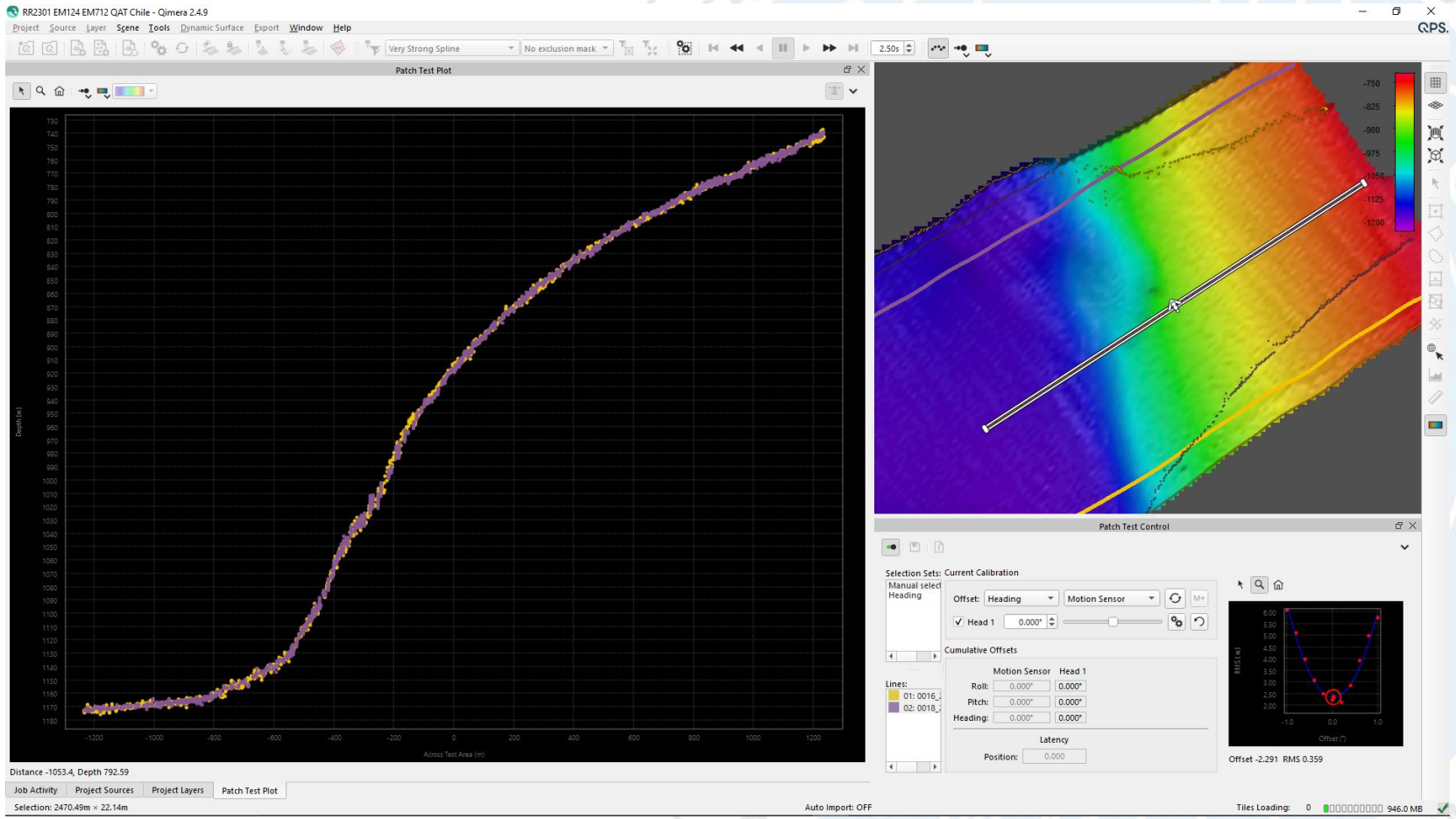


Roll calibration lines shown at left in the Qimera Patch Test Tool

1. Attitude 1 initial setting: +0.15°
2. Calibration adjustment: 0.00°
3. **Final roll offset: +0.15° in SIS**

EM124 Calibration

Results: Heading (Seapath)

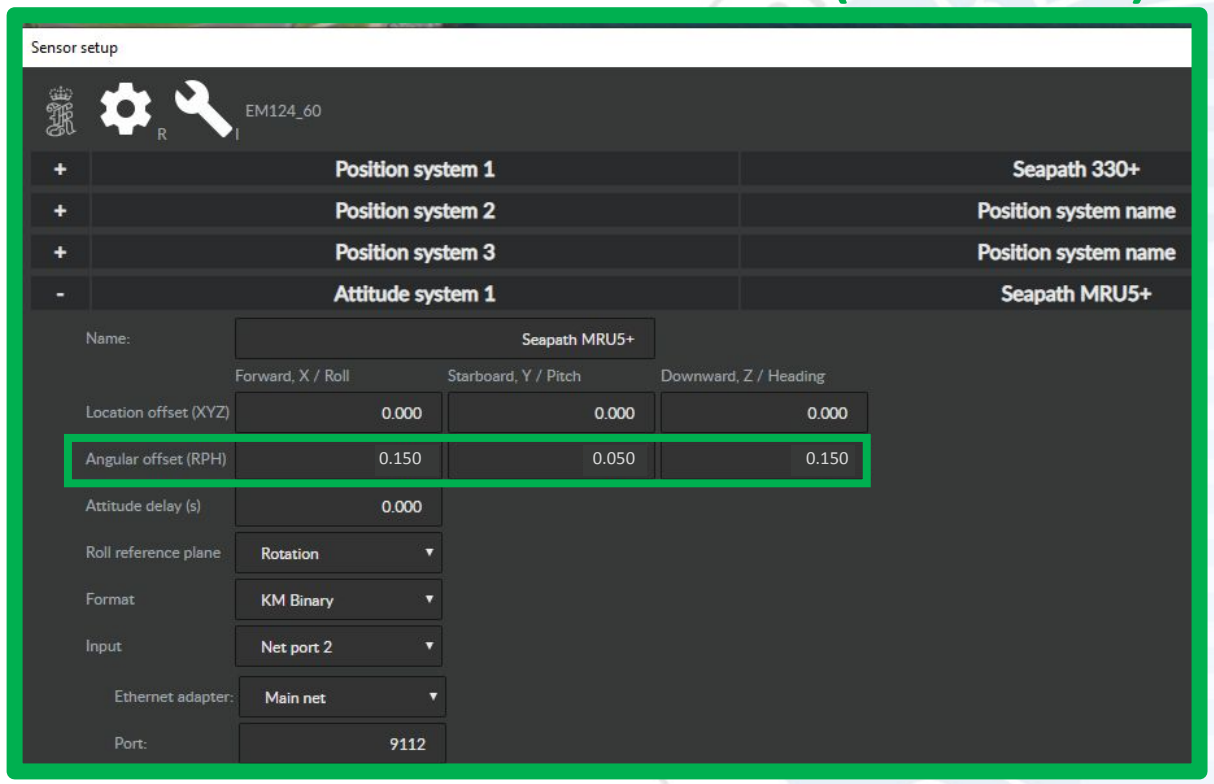


Heading calibration lines shown at left in the Qimera Patch Test Tool

1. Attitude 1 initial setting: +0.05°
2. Calibration adjustment: +0.10°
3. **Final hdg. offset: +0.15° in SIS**

EM124 Calibration

POST-CALIBRATION (EM124)

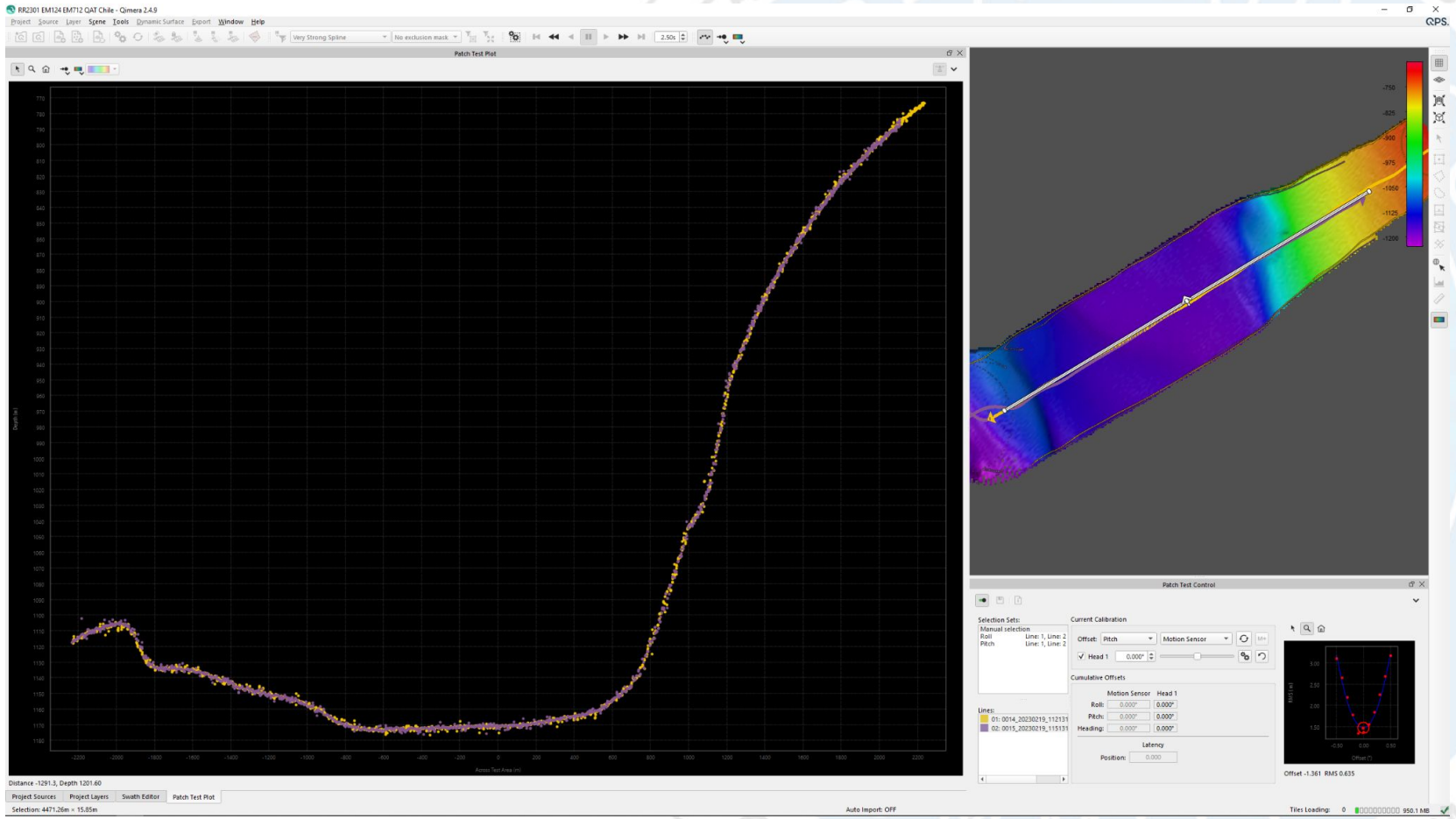


Post-Calibration Configuration

1. The *Attitude 1* adjustments made during the 2023 EM124 QAT are generally small and in line with the typical range of results; these results suggest correct vessel survey results and consistent integration
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)

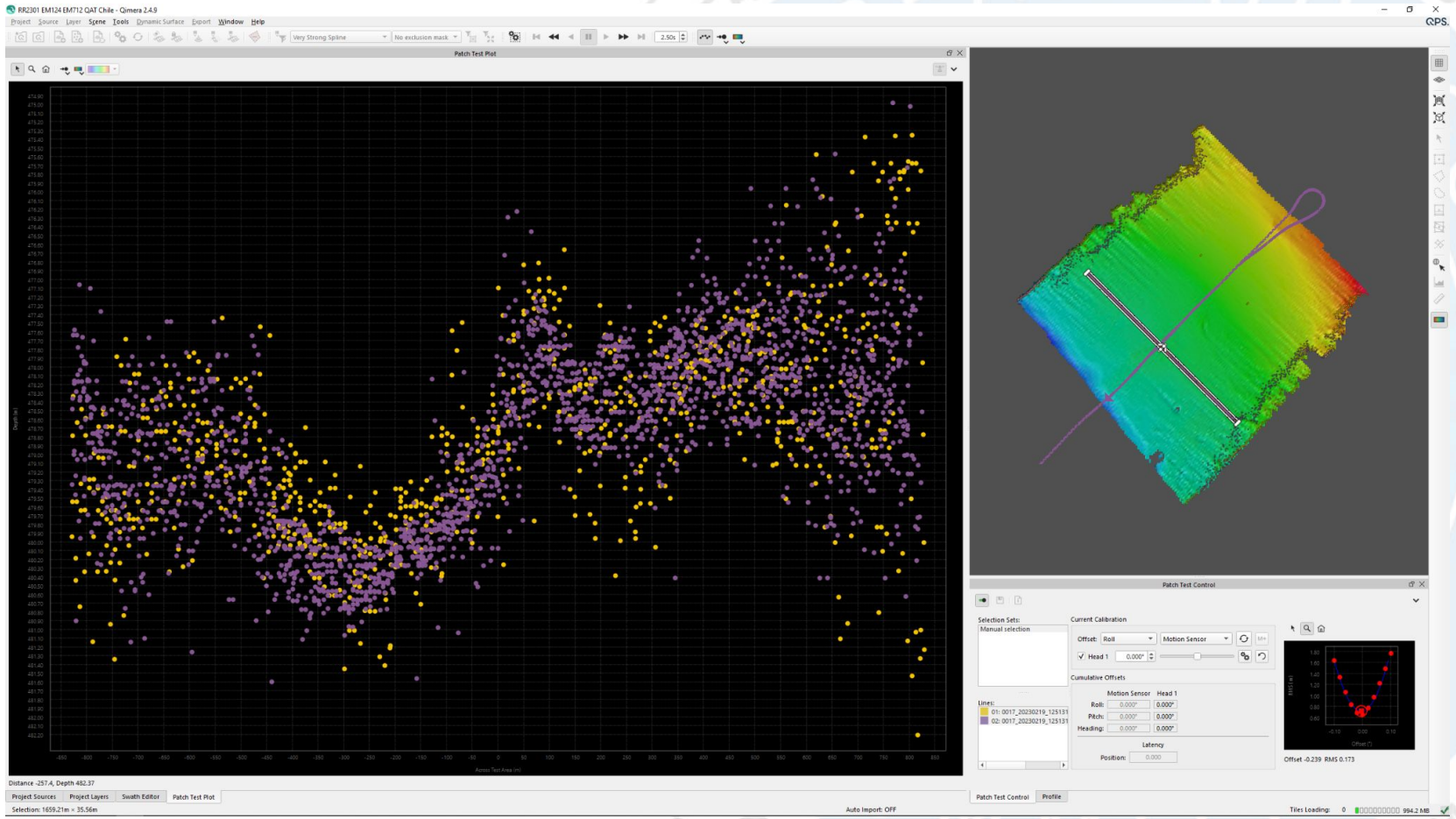


Pitch calibration lines shown at left in the Qimera Patch Test Tool

1. Attitude 1 initial setting: 0.00°
2. Calibration adjustment: +0.01°
3. **Final pitch offset: +0.01° in SIS**

EM712 Calibration

Results: Roll (Seapath)

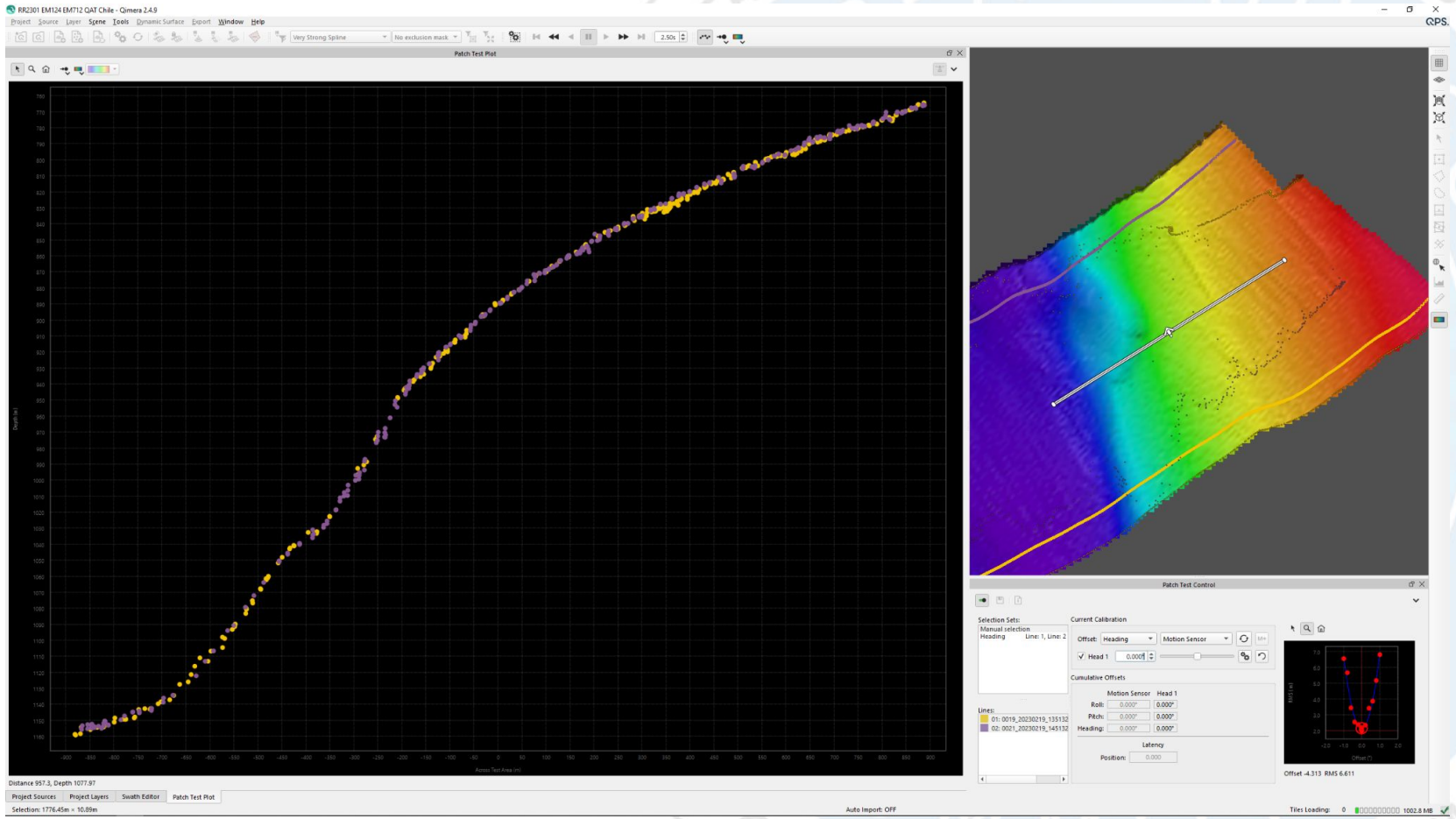


Roll calibration lines shown at left in the Qimera Patch Test Tool

1. Attitude 1 initial setting: +0.15°
2. Calibration adjustment: +0.02°
3. **Final roll offset: +0.17° in SIS**

EM712 Calibration

Results: Heading (Seapath)

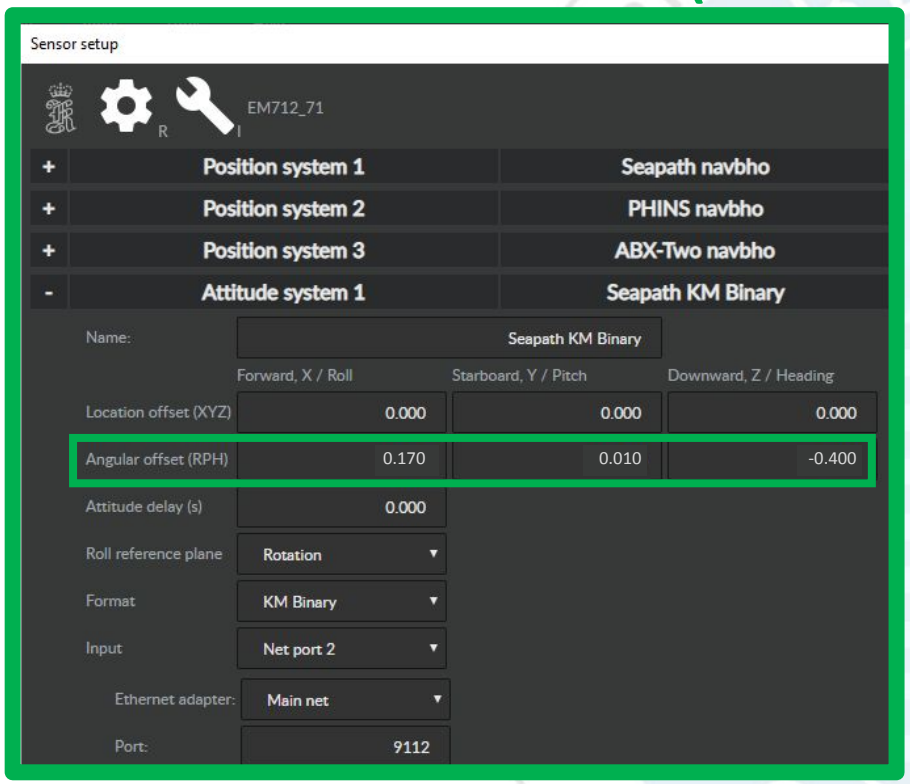


Heading calibration lines shown at left in the Qimera Patch Test Tool

1. Attitude 1 initial setting: -0.35°
2. Calibration adjustment: -0.05°
3. **Final hdg. offset: -0.40° in SIS**

EM712 Calibration

POST-CALIBRATION (EM712)



Post-Calibration Configuration

1. The *Attitude 1* adjustments made during the 2023 EM712 QAT are generally small and in line with the typical range of results; these results suggest correct vessel survey results and consistent integration
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

photo: Erik Jepsen, UCSD Publications