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2016 EK60 Calibration Report

NOAA Ship *Okeanos Explorer*

EX-16-01: Transit and Mission Test

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Introduction

NOAA Ocean Exploration is the only federal program dedicated to exploring the deep ocean, closing prominent gaps in our basic understanding of U.S. deep waters and the seafloor and delivering the ocean information needed to strengthen the economy, health, and security of our nation.

Using the latest tools and technology, NOAA Ocean Exploration explores previously unknown areas of our deep ocean, making discoveries of scientific, economic, and cultural value. Through live video streams, online coverage, training opportunities, and real-time events, NOAA Ocean Exploration allows scientists, resource managers, students, members of the general public, and others to actively experience ocean exploration, expanding available expertise, cultivating the next generation of ocean explorers, and engaging the public in exploration activities. To better understand our ocean, we make exploration data available to the public. This allows us, collectively, to more effectively maintain ocean health, sustainably manage our marine resources, accelerate our national economy, and build a better appreciation of the value and importance of the ocean in our everyday lives.

This document provides all the information for the NOAA Ocean Exploration 2016 calibration of the Simrad EK60 echosounder on NOAA Ship *Okeanos Explorer* during EX-16-01 provided by Kongsberg. The calibration occurred on February 3 and 4, 2016 off of the Island of Lanai. During this procedure, the 18, 70, 120, and 200 kilohertz (kHz) were calibrated at maximum power. The 18 kHz was calibrated at 2.048 and 4.096 ms, the 70 kHz at 2.048 ms, and the 120 and 200 kHz at 1.024 ms pulse lengths. The 38 kHz was not calibrated due to a defective general purpose transceiver (GPT) and the 333 kHz transducer calibration was attempted but the root mean squared error values were too high to be considered successful.

Location and Conditions

- The ship was located off of the island of Lanai, Hawaii at coordinates 20.8441°, -157.2585° for the calibration on February 3 and 4, 2016.
- A conductivity, temperature, depth (CTD) cast was performed before commencing calibration to obtain the required water properties necessary for calibration, including the temperature and salinity at the depth of the sphere.
- Average speed of sound at the calibration depth (~15 meters) for the 18, 70, 120, and 200 kHz transducers was 1535.0 meters per second.

Calibration Parameters

- The 18 kHz was calibrated at 2.048 and 4.096 ms, the 70 kHz at 2.048 ms, and the 120 and 200 kHz at 1.024 ms. The 38 kHz was not calibrated due to a defective general purpose transceiver (GPT) and the 333 kHz transducer calibration was attempted but the root mean square error values were too high to be useful.
- Ping rate was 1 ping/second.
- Power was set to maximum for each frequency.
- See **Table 1** of this document for a complete list of parameters used during calibration. The table does not include the 38 and 333 kHz frequencies because these were not successfully calibrated.

Table 1. List of relevant parameters and initial settings used during the 2016 calibration of the EK60 echosounders (18, 70, 120, 200 kHz). While calibration was attempted for 38 and 333 kHz, they were not successful and thus not included in the table. For more information, see Appendix A containing the calibration results.

Frequency (kHz)	**18**	**18**	**70**	**70**	**120**	**200**
GPT serial number	009072066c0e	009072066c0e	00907206044a	00907206044a	009072033ffa	009072034253
ER 60 software version	2.1.0.12	2.1.0.12	2.1.0.12	2.1.0.12	2.1.0.12	2.1.0.12
Transducer model	ES18-11	ES18-11	ES70-7C	ES70-7C	ES120-7C	ES200-7C
Transducer serial number	2097	2097	343	343	1256	596
Transducer draft setting (m)	5.65	5.65	5.65	5.65	5.65	5.65
Transmit power (W)	2000	2000	750	750	250	150
Pulse length (ms)	4.096	2.048	2.048	1.024	1.024	1.024
Two-way beam angle (dB)	-17.20	-17.20	-20.50	-20.50	-20.40	-20.40
Transducer peak gain (dB)	23.00	22.90	27.00	27.00	27.00	27.00
Sa correction (dB)	0.00	0.00	0.00	0.00	0.00	0.00
Absorption coefficient (dB/km)	0.0015	0.0015	0.0183	0.0183	0.0445	0.0856
Speed of sound (m/s)	1535.0	1535.0	1535.0	1535.0	1535.0	1535.0
3 dB beamwidth (º) along/athwart	11.00/11.00	11.00/11.00	7.00/7.00	7.00/7.00	7.00/7.00	7.00/7.00
Angle offset (º) along/athwart	0.00/0.00	0.00/0.00	0.00/0.00	0.00/0.00	0.00/0.00	0.00/0.00

Calibration Procedure

To minimize the time and setup required, one sphere (38.1 mm tungsten carbide) was used to calibrate all frequencies except for the 18 and 333 kHz which used a 64 mm copper and a 23 mm tungsten carbide sphere, respectively. The pod below refers to the transducers (38, 70, 120, 200, and 333 kHz) that are near each other on the hull of the ship. The pod is more forward and starboard of the 18 kHz transducer so separate techniques are used to calibrate the pod versus the 18 kHz. Reference Appendix C for the X, Y, and Z hull locations for each of the transducers.

Calibrations were performed using Simrad's ER60 calibration software (version 2.1.0.12). For the setup of the downriggers, consult the NOAA Ocean Exploration Standard Operating Procedure: EK60/EK80 Calibration[1]. The three calibration lines were joined using typical calibration procedures (lowering a rope under the bow with the port side calibration line attached to the end of it and retrieving the rope from the starboard side once passed under the keel). For the 18 kHz calibration, the reciprocal was used with the line being attached to the starboard side and pulling up on the port side. Prior to deployment, the sphere was soaked in a soapy water solution to break surface tension. The sphere was then lowered to a depth of approximately 15 m and 15-20 m from the surface of the water for the pod and 18 kHz calibration, respectively.

The target strength (TS) of the sphere used for calibration was calculated based on the CTD measurements of salinity, temperature, and depth of the sphere. See **Table 2** for the TS values of the sphere for each frequency and consult the Location and Conditions section for the sound speed values. For each frequency, the sphere was initially positioned in the center of the transducer beam (on-axis) and data were recorded for several minutes. The sphere was moved throughout the beam to achieve adequate coverage.

Table 2. Target strength (TS; units=dB) values of the spheres used during calibration based on the values calculated from the speed of sound at the sphere depth.

Frequency (kHz)	64 mm diameter copper sphere TS (dB)	38.1 mm diameter tungsten carbide sphere TS (dB)
18	-34.56	N/A
70	N/A	-41.66
120	N/A	-39.99
200	N/A	-38.95

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Calibration Results

There was very good beam coverage for the 18, 70, 120 and 200 kHz frequencies and root mean square (RMS) error values below the recommended 0.4 threshold (per manufacturer recommendations). All calibration results are detailed in **Table 3**. See Appendix A for beam coverage and error values of each of the calibrated frequencies. All .raw and .txt files were saved and recorded and the updated calibration settings were applied to each transducer. See Appendix B for a complete list of the .raw and .txt files recorded during calibration.

Table 3. 2016 calibration results. All calibration results are included in this table aside from the 38 and 333 kHz frequencies as their calibrations were not successful. See Appendix A for the screenshots detailing the results from the 2016 calibration.

18 kHz: Pulse length: 4.096 ms	**February 2016 results**
Transducer peak gain (dB)	21.87
Sa correction (dB)	-0.36
Beamwidth (º) alongship/athwartship	10.69/11.15
Beam offset (º) alongship/athwartship	0.00/0.14
RMS deviation beam/polynomial model (dB)	0.36/0.34
18 kHz: Pulse length: 2.048 ms	**February 2016 results**
Transducer peak gain (dB)	22.02
Sa correction (dB)	-0.57
Beamwidth (º) alongship/athwartship	10.23/10.95
Beam offset (º) alongship/athwartship	0.03/0.16
RMS deviation beam/polynomial model (dB)	0.24/0.20
70 kHz: Pulse length: 2.048 ms	**February 2016 results**
Transducer peak gain (dB)	26.85
Sa correction (dB)	-0.28
Beamwidth (º) alongship/athwartship	6.37/6.42
Beam offset (º) alongship/athwartship	-0.03/0.04
RMS deviation beam/polynomial model (dB)	0.34/0.29

70 kHz: Pulse length: 1.024 ms	**February 2016 results**
Transducer peak gain (dB)	27.13
Sa correction (dB)	-0.33
Beamwidth (º) alongship/athwartship	6.34/6.47
Beam offset (º) alongship/athwartship	-0.01/0.05
RMS deviation beam/polynomial model (dB)	0.34/0.32
120 kHz: Pulse length: 1.024 ms	**February 2016 results**
Transducer peak gain (dB)	26.33
Sa correction (dB)	-0.31
Beamwidth (º) alongship/athwartship	6.21/6.26
Beam offset (º) alongship/athwartship	-0.06/0.07
RMS deviation beam/polynomial model (dB)	0.21/0.20
200 kHz: Pulse length: 1.024 ms	**February 2016 results**
Transducer peak gain (dB)	26.61
Sa correction (dB)	-0.27
Beamwidth (º) alongship/athwartship	6.20/6.27
Beam offset (º) alongship/athwartship	0.01/0.13
RMS deviation beam/polynomial model (dB)	0.33/0.31

Appendix A: Calibration Results

18 kHz: 4.096 ms

Figure 1. Screenshot of ER60 software calibration results for 18 kHz calibration at 4.096 ms.

18 kHz: 2.048 ms

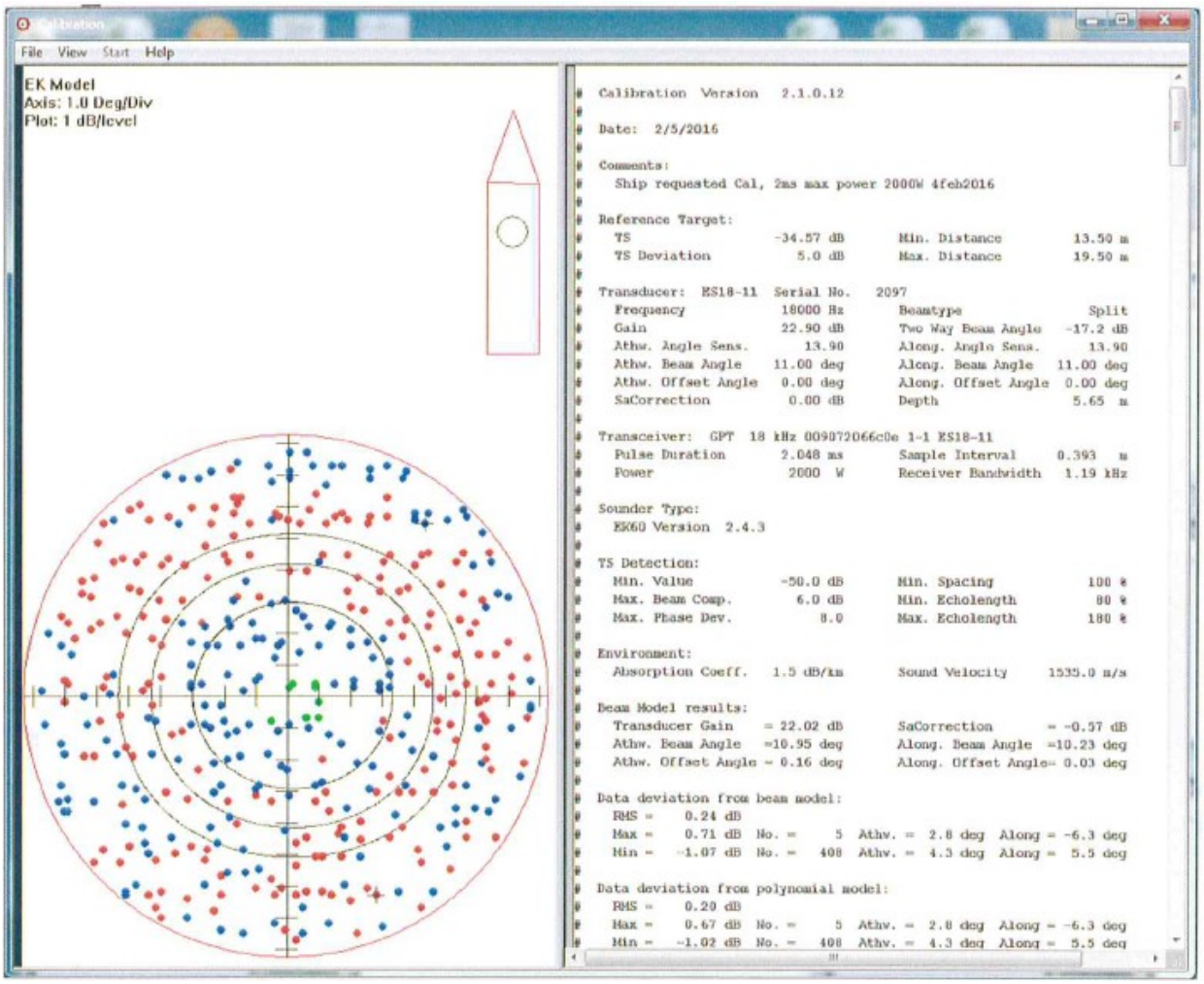

Figure 2. Screenshot of ER60 software calibration results for 18 kHz calibration at 2.048 ms.

70 kHz: 2.048 ms

Figure 3. Screenshot of ER60 software calibration results for 70 kHz calibration at 2.048 ms.

70 kHz: 1.024 ms

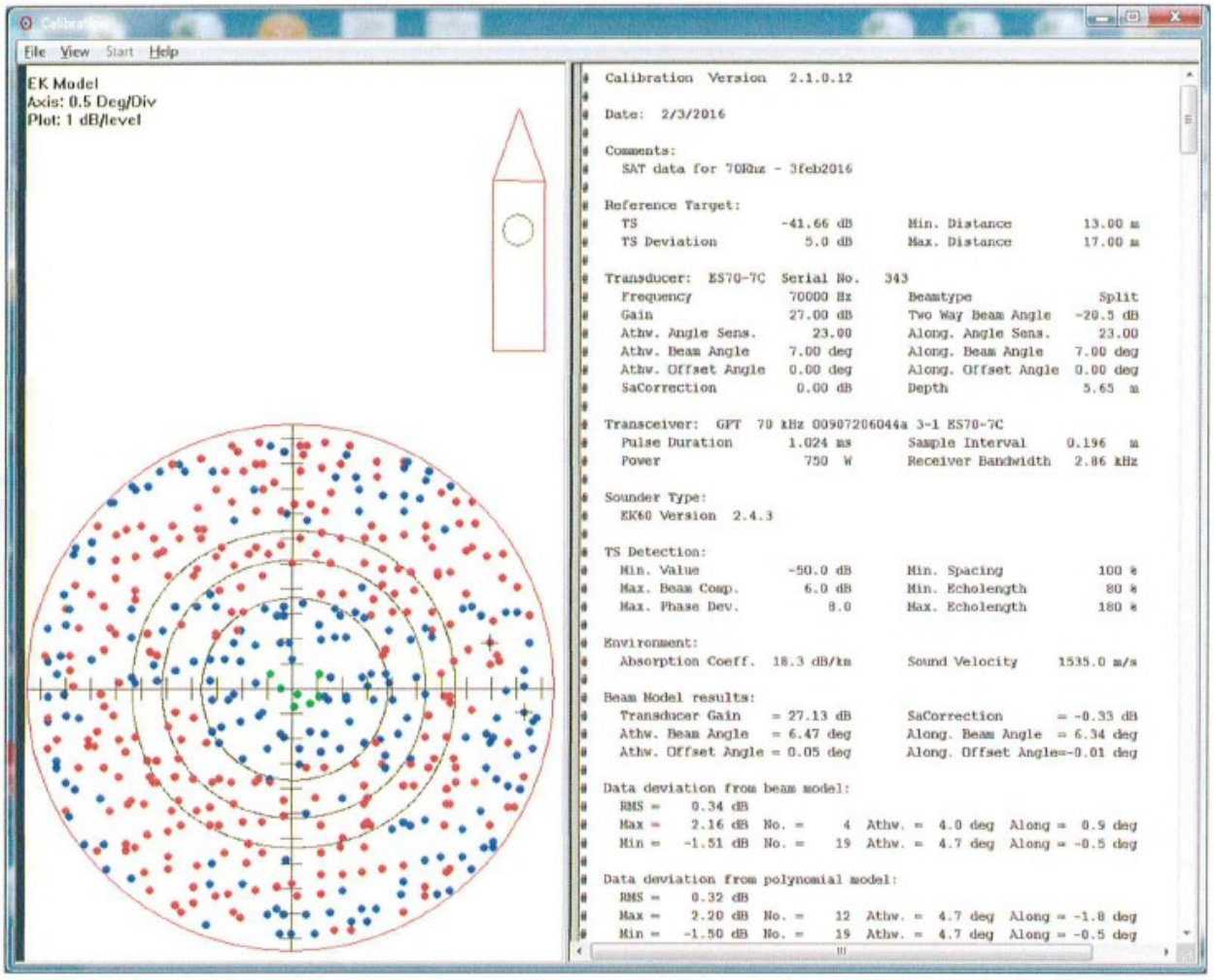

Figure 4. Screenshot of ER60 software calibration results for 70 kHz calibration at 1.024 ms.

120 kHz: 1.024 ms

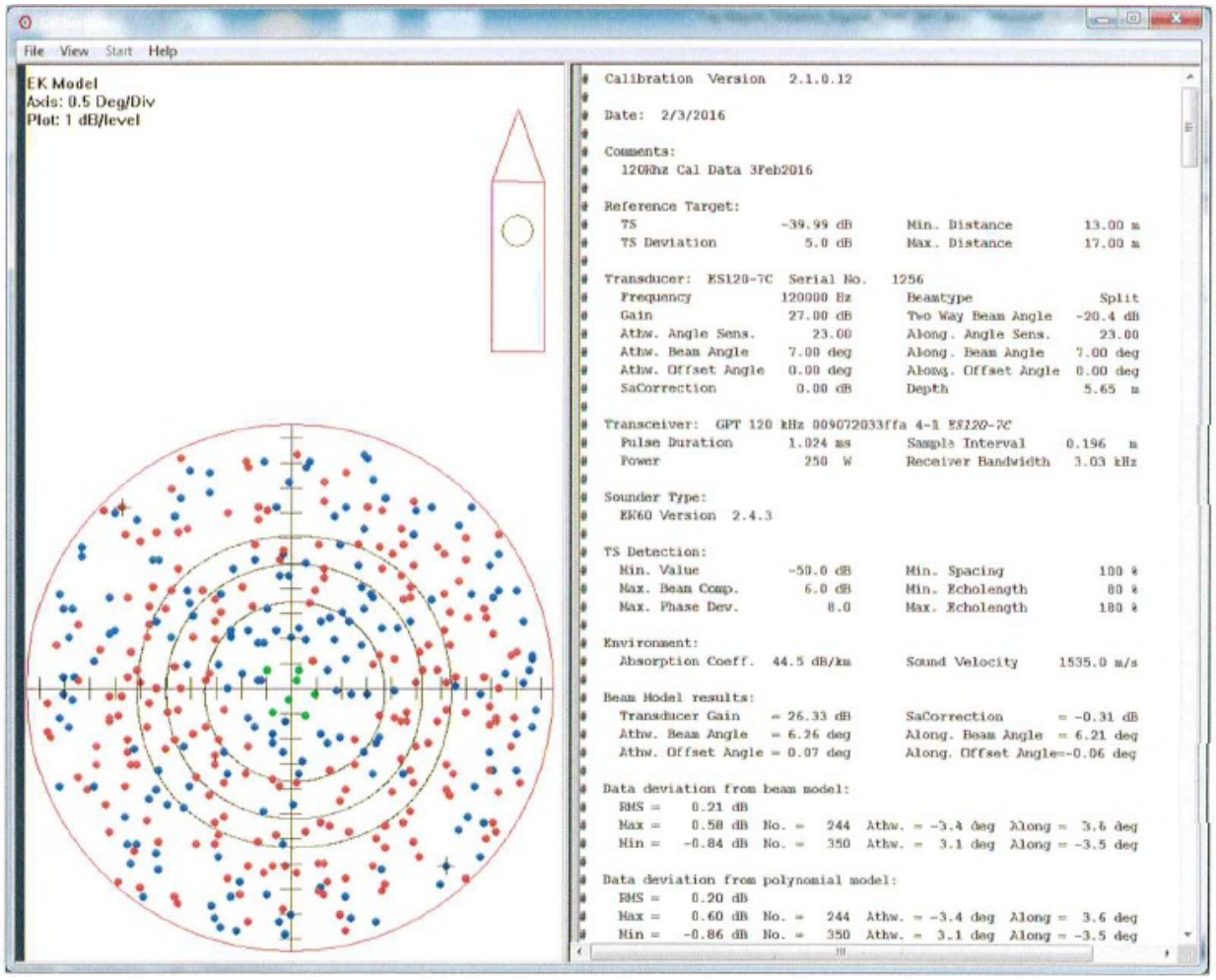

Figure 5. Screenshot of ER60 software calibration results for 120 kHz calibration at 1.024 ms.

200 kHz: 1.024 ms

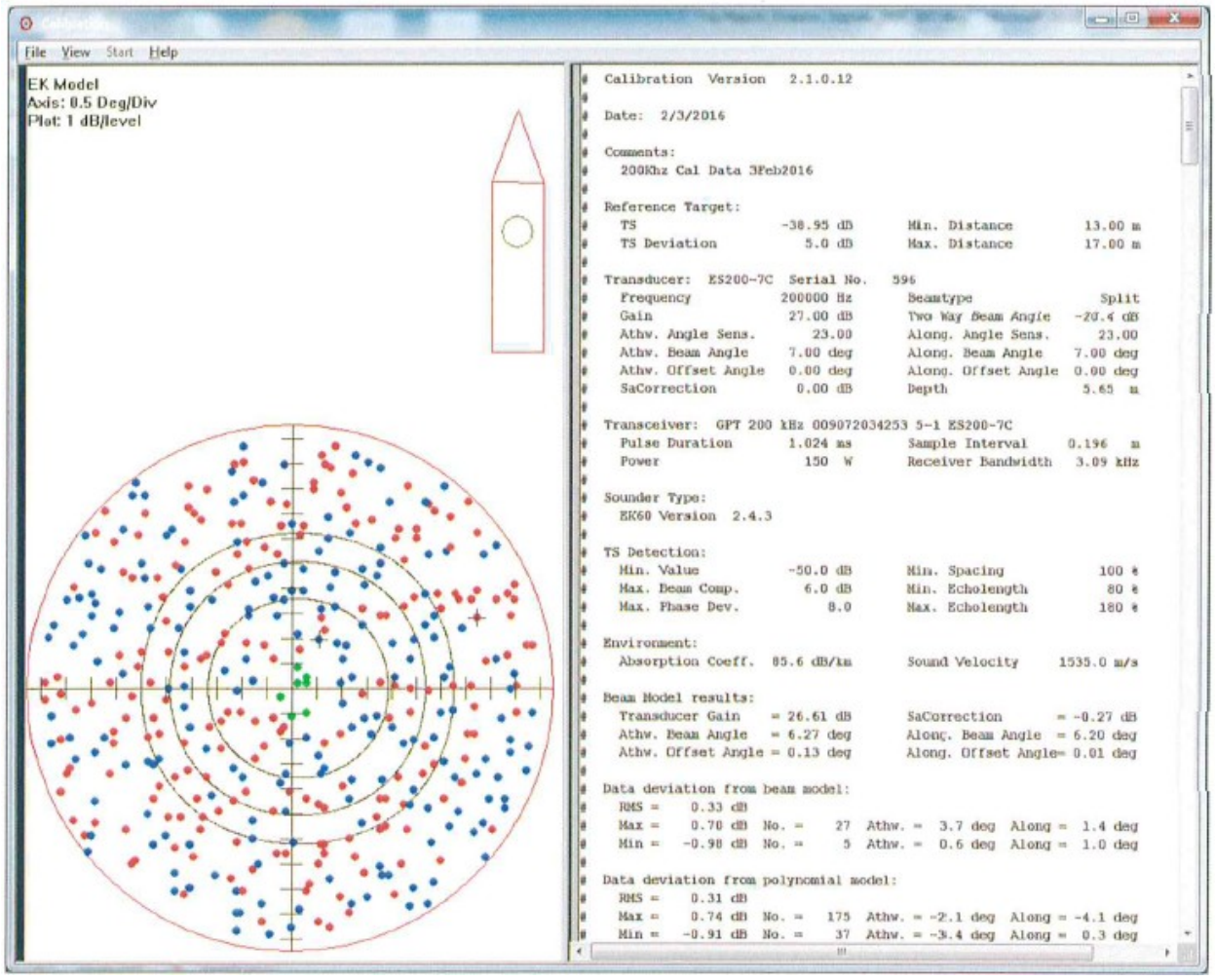

Figure 6. Screenshot of ER60 software calibration results for 200 kHz calibration at 1.024 ms.

333 kHz: 1.024 ms

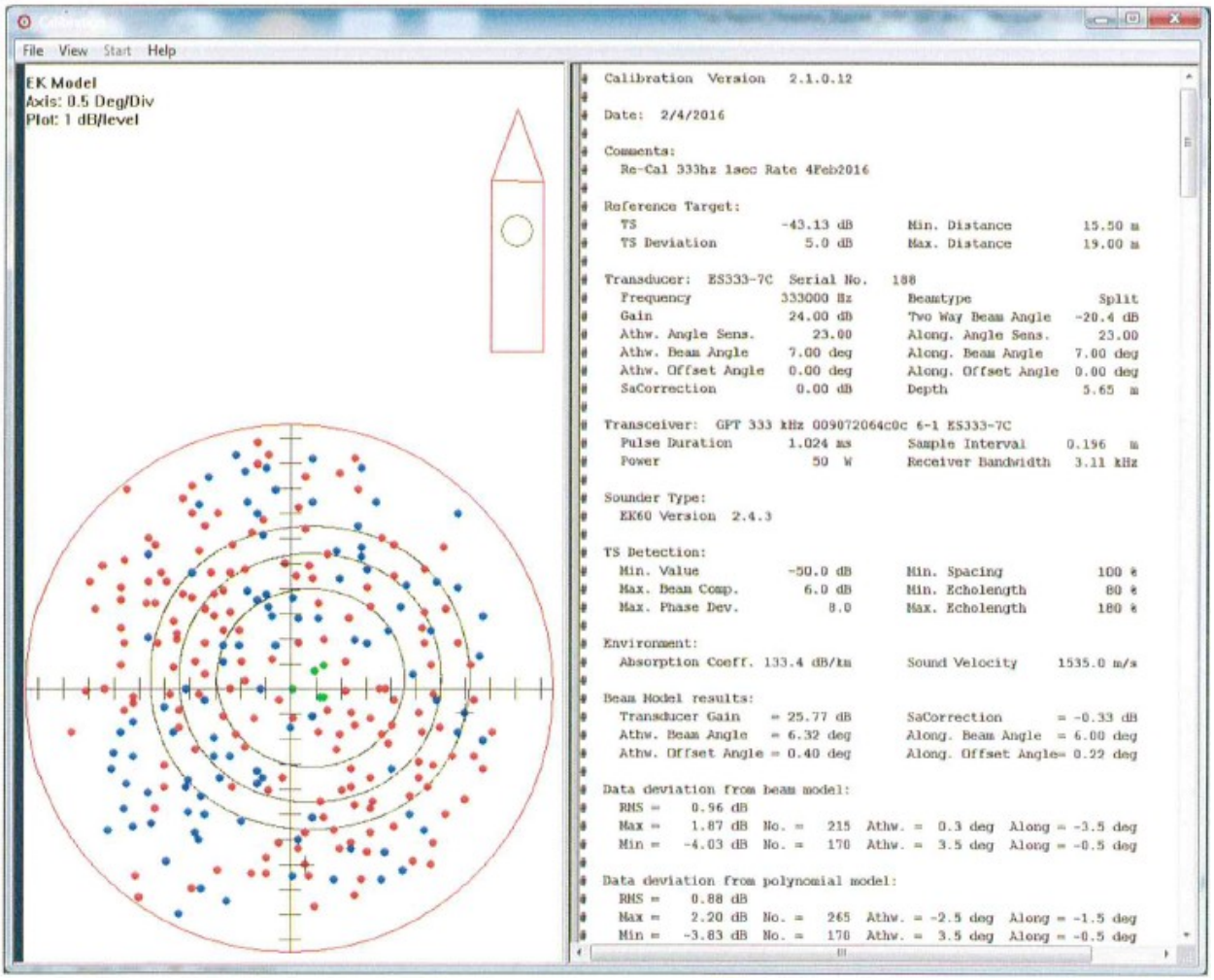

Figure 7. Screenshot of ER60 software calibration results for 333 kHz calibration at 1.024 ms. While the results are provided here, the calibration was deemed unsuccessful due to the very high (greater than 0.40) root mean square error values.

Appendix B: Detailed List of .raw and .txt Calibration Files

File name	Date (UTC)	Frequency (pulse length)
70Khz_SN-343_1.024ms_750W/EX1601_EK60_70Khz_SAT-D20160203-T195730.bot	02/03/2016	70 kHz (1.024 ms)
70Khz_SN-343_1.024ms_750W/EX1601_EK60_70Khz_SAT-D20160203-T195730.idx	02/03/2016	70 kHz (1.024 ms)
70Khz_SN-343_1.024ms_750W/EX1601_EK60_70Khz_SAT-D20160203-T195730.raw	02/03/2016	70 kHz (1.024 ms)
70Khz_SN-343_1.024ms_750W/EX1601_EK60_70Khz_SAT-D20160203-T202446.bot	02/03/2016	70 kHz (1.024 ms)
70Khz_SN-343_1.024ms_750W/EX1601_EK60_70Khz_SAT-D20160203-T202446.idx	02/03/2016	70 kHz (1.024 ms)
70Khz_SN-343_1.024ms_750W/EX1601_EK60_70Khz_SAT-D20160203-T202446.raw	02/03/2016	70 kHz (1.024 ms)
120Khz_SN-1256_1.024ms_250W/EX1601_EK60_120Khz_SAT-D20160203-T221119.bot	02/03/2016	120 kHz (1.024 ms)
120Khz_SN-1256_1.024ms_250W/EX1601_EK60_120Khz_SAT-D20160203-T221119.idx	02/03/2016	120 kHz (1.024 ms)
120Khz_SN-1256_1.024ms_250W/EX1601_EK60_120Khz_SAT-D20160203-T221119.raw	02/03/2016	120 kHz (1.024 ms)
200Khz_SN-596_1.024ms_150W/EX1601_EK60_200Khz_SAT-D20160203-T203957.bot	02/03/2016	200 kHz (1.024 ms)
200Khz_SN-596_1.024ms_150W/EX1601_EK60_200Khz_SAT-D20160203-T203957.idx	02/03/2016	200 kHz (1.024 ms)
200Khz_SN-596_1.024ms_150W/EX1601_EK60_200Khz_SAT-D20160203-T203957.raw	02/03/2016	200 kHz (1.024 ms)
70Khz_SN-343_2.048ms_750W/EX1601_EK60_70Khz_2ms_750W-D20160204-T004747.bot	02/04/2016	70 kHz (2.048 ms)
70Khz_SN-343_2.048ms_750W/EX1601_EK60_70Khz_2ms_750W-D20160204-T004747.idx	02/04/2016	70 kHz (2.048 ms)
70Khz_SN-343_2.048ms_750W/EX1601_EK60_70Khz_2ms_750W-D20160204-T004747.raw	02/04/2016	70 kHz (2.048 ms)
18Khz_SN-2097_2.048ms_2000W/EX1601_EK60_18Khz_Data-D20160205-T022659.bot	02/05/2016	18 kHz (2.048 ms)
18Khz_SN-2097_2.048ms_2000W/EX1601_EK60_18Khz_Data-D20160205-T022659.idx	02/05/2016	18 kHz (2.048 ms)
18Khz_SN-2097_2.048ms_2000W/EX1601_EK60_18Khz_Data-D20160205-T022659.raw	02/05/2016	18 kHz (2.048 ms)
18Khz_SN-2097_4.096ms_2000W/EX1601_EK60_18Khz_Data-D20160205-T014925.bot	02/05/2016	18 kHz (4.096 ms)
18Khz_SN-2097_4.096ms_2000W/EX1601_EK60_18Khz_Data-D20160205-T014925.idx	02/05/2016	18 kHz (4.096 ms)

File name	Date (UTC)	Frequency (pulse length)
18Khz_SN-2097_4.096ms_2000W/EX1601_EK60_18Khz_Data-D20160205-T014925.raw	02/05/2016	18 kHz (4.096 ms)

Calibration .txt file name	Date (UTC)
120Khz_SN-1256_1.024ms_250W/EX1601_EK-Cal-120Khz_SN-1256_1.024ms_250W.txt	02/03/2016
200Khz_SN-596_1.024ms_150W/EX1601_EK-Cal-200Khz_SN-596_1.024ms_150W.txt	02/03/2016
70Khz_SN-343_1.024ms_750W/EX1601_EK-Cal_70Khz_SN-343_1.024ms_750W.txt	02/03/2016
70Khz_SN-343_2.048ms_750W/EX1601_EK-Cal_70Khz_SN-343_2ms_750W.txt	02/04/2016
18Khz_SN-2097_2.048ms_2000W/EX1601_EK-Cal_18Khz_SN-2097_2ms_2000W.txt	02/05/2016
18Khz_SN-2097_4.096ms_2000W/EX1601_EK-Cal_18Khz_SN-2097_4ms_2000W.txt	02/05/2016

Appendix C: Vessel Offsets for Transducer Hull Locations

Vessel Offsets (meters)			
Transducer	**X**	**Y**	**Z**
ES18-11 (18 kHz)	-0.5234	1.7793	6.7833
ES70-7C (70 kHz)	6.5095	3.3939	6.7903
ES120-7C (120 kHz)	5.2481	3.3954	6.7895
ES200-7C (200 kHz)	6.1682	3.2258	6.7920