SKQ202008S Planning Overview

• The University of Alaska’s UNOLS vessel R/V Sikuliaq (SKQ) is equipped with Kongsberg Maritime EM302 and EM710 multibeam echosounders and a Seapath 320 positioning / attitude system

• The Multibeam Advisory Committee (MAC) was asked to assist with Quality Assurance Testing (QAT) of the ship’s EM302 and EM710 ahead of the 2020 field season; due to widespread travel restrictions, MAC personnel provided remote support for line planning and data analysis from shore

• MAC communication with SKQ personnel (Steven Hartz) commenced in spring 2020 with planning for calibrations (‘patch tests’) for both systems near Seward, Alaska

• The calibration test plan was developed using suitable seafloor features in depth ranges appropriate for simultaneous data collection with both systems; shallow and deep roll sites were added for verification

• This report describes the calibration results and implementation in SIS
SKQ202008S Planning Overview

• EM302 / EM710 calibration lines were planned over features selected from bathymetric compilations in the Global Multi-Resolution Topography Synthesis (gmrt.org)
System Geometry Review

Overview: Vessel Survey

- The granite block remains the origin for all sensor reference frames; Seapath output is valid at the granite block.

- Following the 2019 calibration (SKQ201907T), no changes were made to Seapath, EM302, or EM710 installation offsets prior to calibration data collection during SKQ202008S.

- Refer to MAC reports (mac.unols.org) for the 2014 SAT (SKQ201400L3), 2016 QAT (SKQ201602S), 2018 QAT (SKQ201802T), and 2019 QAT (SKQ201907T) for a more complete history of the vessel and sensor geometry.
Seapath 320 Configuration

MRU Lever Arms and Angles

The Seapath MRU is the only mapping system component to have undergone any modification since the 2016 QAT.

In 2018, the MRU ‘bottle’ was removed and shipped to Kongsberg for a factory calibration, then reinstalled in its mounting bracket prior to SKQ201802T.

Because the MRU bottle is a reasonably tight fit in the bracket (expected to be repeatable to within a few hundredths of a degree), and the bracket was not altered, MAC and SKQ personnel agreed in 2018 to maintain the existing MRU installation angles in the Seapath Nav Engine ahead of the 2018 calibrations; likewise, no changes were made prior to the 2019 and 2020 calibrations.

Screenshot at left shows MRU geometry as configured through SKQ202008S.
Seapath 320 Configuration

Antenna Lever Arms

Seapath GNSS antenna offsets are based on the original vessel survey and an updated survey after antenna relocation in 2016.

See the SKQ201602S QAT report for more details of the antenna geometry.

No changes have been made to antenna offsets after SK201602S.

Screenshot at left shows Seapath GNSS antenna geometry as configured through SKQ202008S.
1. Calibration sites were selected based on availability of seafloor features near Seward, Alaska, with optimal slopes and depths within the suitable operational ranges of both echosounders.

2. Roll verification lines were run in shallow and deep waters to further exaggerate roll biases for each system.

3. XBT profiles were collected throughout calibration, processed in Sound Speed Manager, and applied in SIS during data collection; these profiles were applied using ‘nearest in time’ scheduling during Qimera processing.

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<th>Waypoint</th>
<th>Decimal Degrees</th>
<th>Degrees Decimal Minutes</th>
<th>EM302/EM710 Pitch</th>
<th>EM302/EM710 Roll</th>
<th>EM302/EM710 Heading Line 1</th>
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Note: Although the surfaces in this report indicate that the course over ground was not as perpendicular to the bathymetric contours as originally intended, it is clear the vessel ran the waypoints exactly as planned/delivered and the calibration data were fully useful for their intended purposes. The MAC will modify the planning process to reduce the effects of projections at higher latitudes and better align the actual course over ground across bathymetric contours.
EM302 / EM710 Calibration

Pre-Calculation Configuration

1. All Attitude 1 angular offsets were left unchanged in *SIS Installation Parameters* prior to data collection.

2. Calibration data were examined on shore with patch test tools in QPS Qimera; results were agreed upon by multiple personnel before communication to SKQ.

3. During analysis on shore, results from each test were applied in the Qimera vessel configuration for each system prior to subsequent tests, then reviewed in an iterative process to minimize the effects of coupling between offsets.

4. Results were updated in the *SIS Installation Parameters* for Attitude 1 after SKQ202008S.

5. No latency test was performed, as it is not clear that any small positioning latency would be evident in deep water; no latency-related bathymetric artifacts were noted.
EM302 Calibration

Results: Pitch

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

1. Attitude 1 initial setting: -0.08°
2. Calibration adjustment: 0.00°
3. Final pitch offset: -0.08° in SIS
EM302 Calibration

Results: Roll

Roll calibration lines shown at left in the Qimera Patch Test Tool (Deep Roll lines were reviewed after initial calibration results were applied and indicated zero further adjustment; Shallow Roll lines were reviewed but were not ideal for the EM302)

1. Attitude 1 initial setting: +0.09°
2. Calibration adjustment: -0.01°
3. Deep ver. adjustment: 0.00°
4. Final roll offset: +0.08° in SIS
EM302 Calibration

Results: Heading

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

1. Attitude 1 initial setting: -0.05°
2. Calibration adjustment: +0.05°
3. Final hdg. offset: 0.00° in SIS
**EM302 Calibration**

**POST-CALIBRATION (EM302)**

1. The small *Attitude 1* adjustments made during the 2020 EM302 calibration confirm a high-quality vessel offset survey, consistent integration, and no significant changes across the Seapath and EM302 since 2019.

2. The *Installation Parameters: Angular Offsets* shown at left should be maintained until any modification is made to the Seapath 320 or EM302 arrays, or another calibration becomes necessary for other reasons.
EM710 Calibration

Results: Pitch

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

1. Attitude 1 initial setting: -0.04°
2. Calibration adjustment: -0.03°
3. Final pitch offset: -0.07° in SIS
EM710 Calibration

Results: Roll

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

1. Attitude 1 initial setting: +0.12°
2. Calibration adjustment: 0.00°*
3. Shallow ver. adjustment: 0.00°*
4. Final roll offset: +0.12° in SIS

*Initial roll calibration at the EM302/EM710 combined site was inconclusive for the EM710 due to limited swath width. Shallow roll verification data provided wider swath angles but suffered from 'noisy' outer soundings. Small subsets of shallow roll data varied in their calibration results (see slight ‘wobbles’ in surface shown and distribution of outer soundings in calibration subset). This may be due in part to aeration along the EM710 RX array, noise limitations, and/or sound speed variability at the shallow site that cannot be captured in a single profile. Although scrutiny of individual subsets produced mixed results, the Qimera Patch Test Tool ‘Autosolver’ calculated a minimum RMS error with 0.00° adjustment using all (cleaned) data at the shallow site.
EM710 Calibration

Results: Heading

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

1. Attitude 1 initial setting: +0.03°
2. Calibration adjustment: 0.00°
3. Final hdg. offset: +0.03° in SIS

Despite limited overlap on the northeast slope (left in subset) in the cleaned dataset shown here, soundings on both slopes suggest that no appreciable heading adjustment is necessary. Larger subsets run through the Qimera Patch Test Tool ‘Autosolver’ generally confirmed this result using cleaned data.
1. As with the EM302, the small adjustments for \textit{Attitude 1} indicated from the EM710 calibration confirm a high-quality vessel offset survey, consistent integration, and no significant changes across the Seapath and EM710 since 2019.

2. The Installation Parameters: Angular Offsets shown at left should be maintained until any modification is made to the Seapath 320 or EM710 arrays, or another calibration becomes necessary for other reasons.