In Situ Array Calibration for Synthetic Aperture Sonar

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Outline

• SAS Technology
• Amplitude Calibration
• Phase Calibration
• Results (Data and Simulation)
Synthetic Aperture Sonar Technology

SAS coherently combines acoustic pings to create ultra-high resolution images

Produces a synthetic aperture proportional to the platform distance traveled
Example AquaPix® Installations
MINSAS Modular Receiver Array
MINSAS 120 Configuration

Area Coverage Rate vs. Array Length

<table>
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<th>Modules per side</th>
<th>ACR (km²/h)</th>
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<tbody>
<tr>
<td>1</td>
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<td>2</td>
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Receiver array is spatially oversampled by 50%
KATFISH™ – High Speed SAS Towfish

Commercial & Military Certified Versions

• Very High Resolution and ACR
  3.0 x 3.3 cm / 1.9 cm x 2.1 cm
  @ up to 4 km² / h with nadir gap fill

• Advanced Obstacle Avoidance and Terrain Following

• Designed for USVs and Remote Operations

• Real Time SAS Waterfall Display with embedded ATR
Port SAS Image Before Calibration
Amplitude Calibration

- Equalize signal levels from seabed backscatter
- No significant differences between channels
- Amplitude calibration did not fix grating lobes
Data Compensation

- Phase center approximation
- Motion compensation
- Interferometry to estimate angle-of-arrival
- Rotation is projected normal to slant range plane
Phase Calibration

• Adjacent channels are partially correlated
• Estimate channel-to-channel phase difference
• Correct for wavefront curvature
• Integrate phase differences along the array
Phase Calibration

- Positive phase is an inward deflection
- Maximum deflection is 1.3 mm
- Linear slope is a rotation of the module by $1.4^\circ$

![Graph showing phase calibration over channel number](image)
Installation Offset

- Modules are normally mounted on a rigid plate
- Small depression in port side cavity
- Undetected at the time of installation
Simulated MINSAS Impulse Response

- **No Phase Error**

- **Triangular Phase Error (105° peak)**

Grating lobe spacing 0.25 m
Port SAS Image Before Calibration

Grating lobe spacing 0.25 m
Port SAS Image After Calibration
Conclusion

• Array is calibrated as installed on AUV
• Amplitude calibration from channel equalization
• Phase calibration from backscatter correlation
• Can be applied in post-processing or real-time
• Applicable to any SAS with an oversampled receiver array
Thank You!

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NOAA Technology Demonstration - July 2019 - USS Bass