In Situ Array Calibration for Synthetic Aperture Sonar

Jeremy Dillon and Shannon-Morgan Steele

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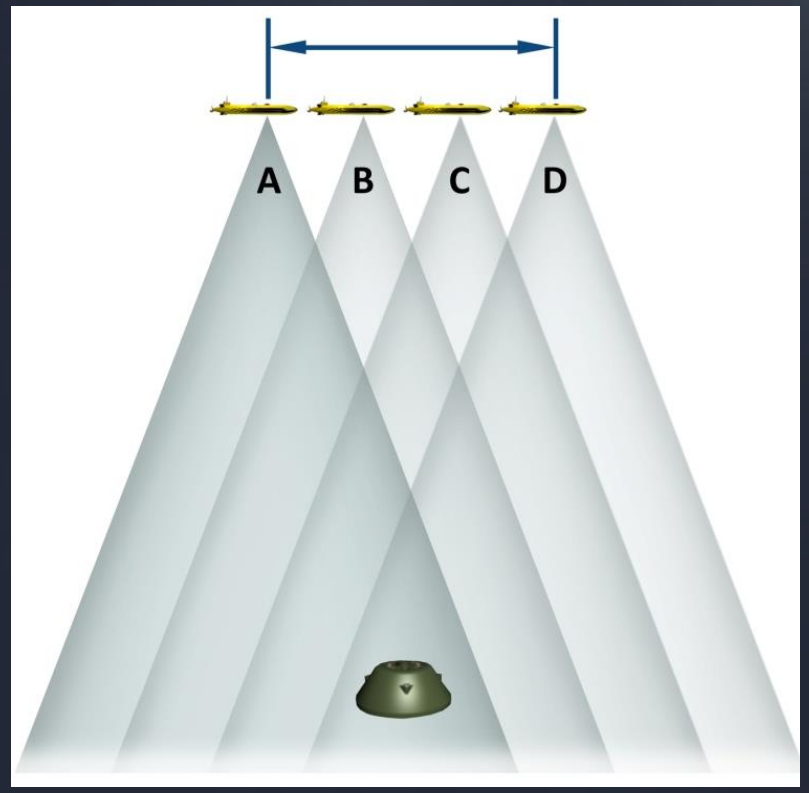
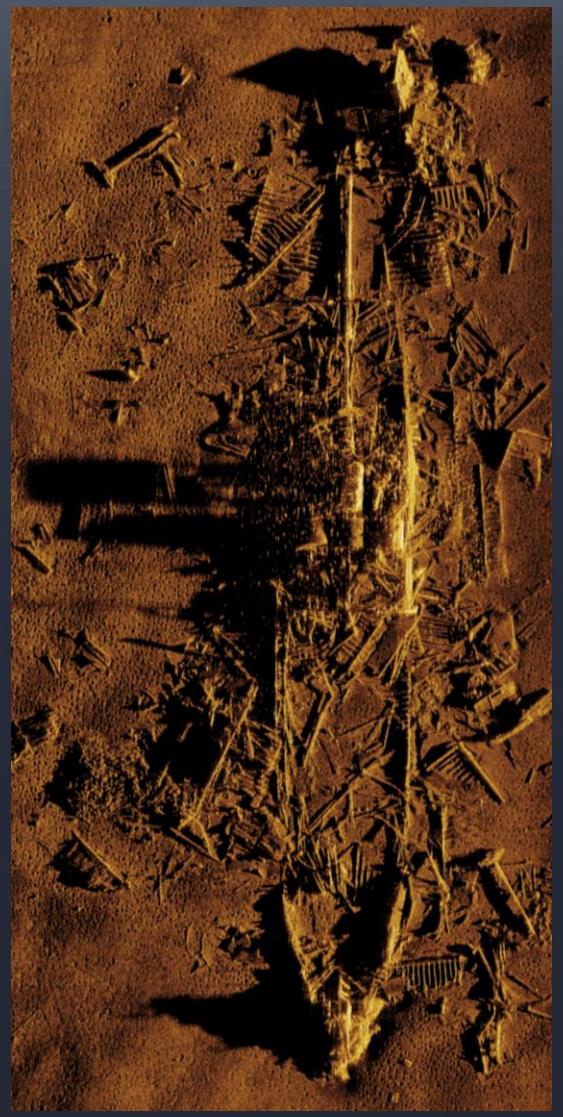
Outline

- SAS Technology
- Amplitude Calibration
- Phase Calibration
- Results (Data and Simulation)

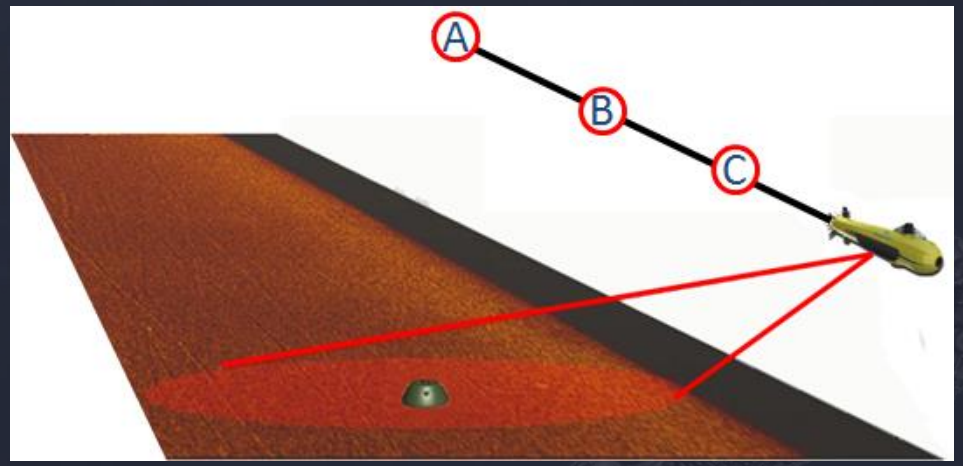
Synthetic Aperture Sonar Technology

Produces a synthetic aperture proportional to the platform distance traveled

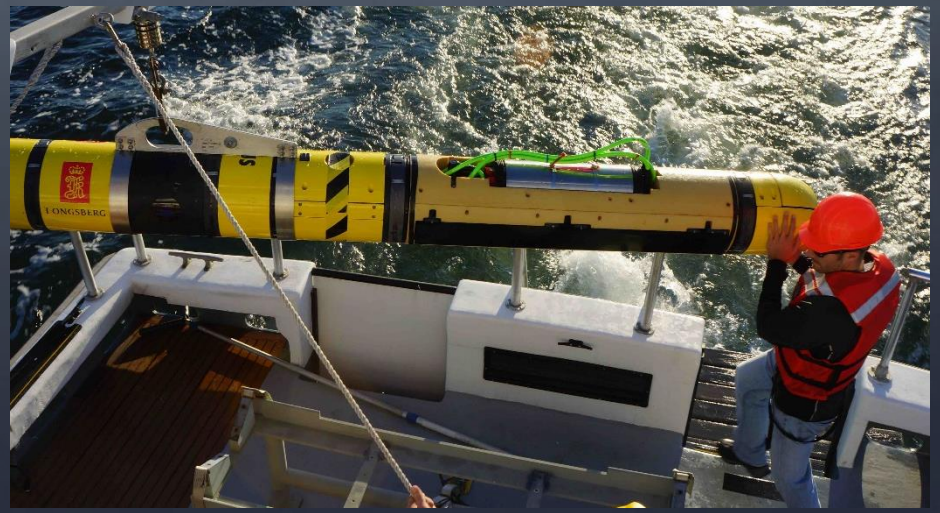




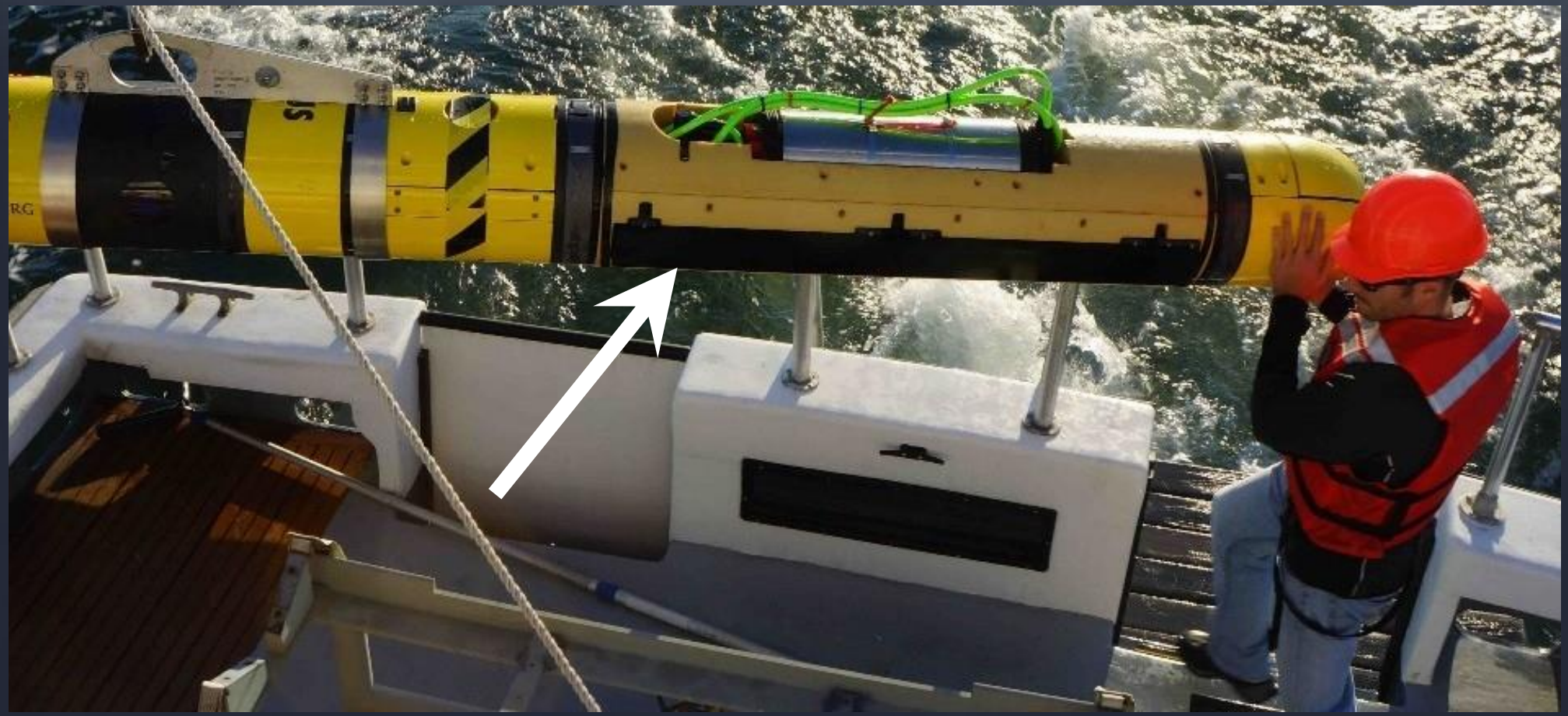
SAS coherently combines acoustic pings to create ultra-high resolution images



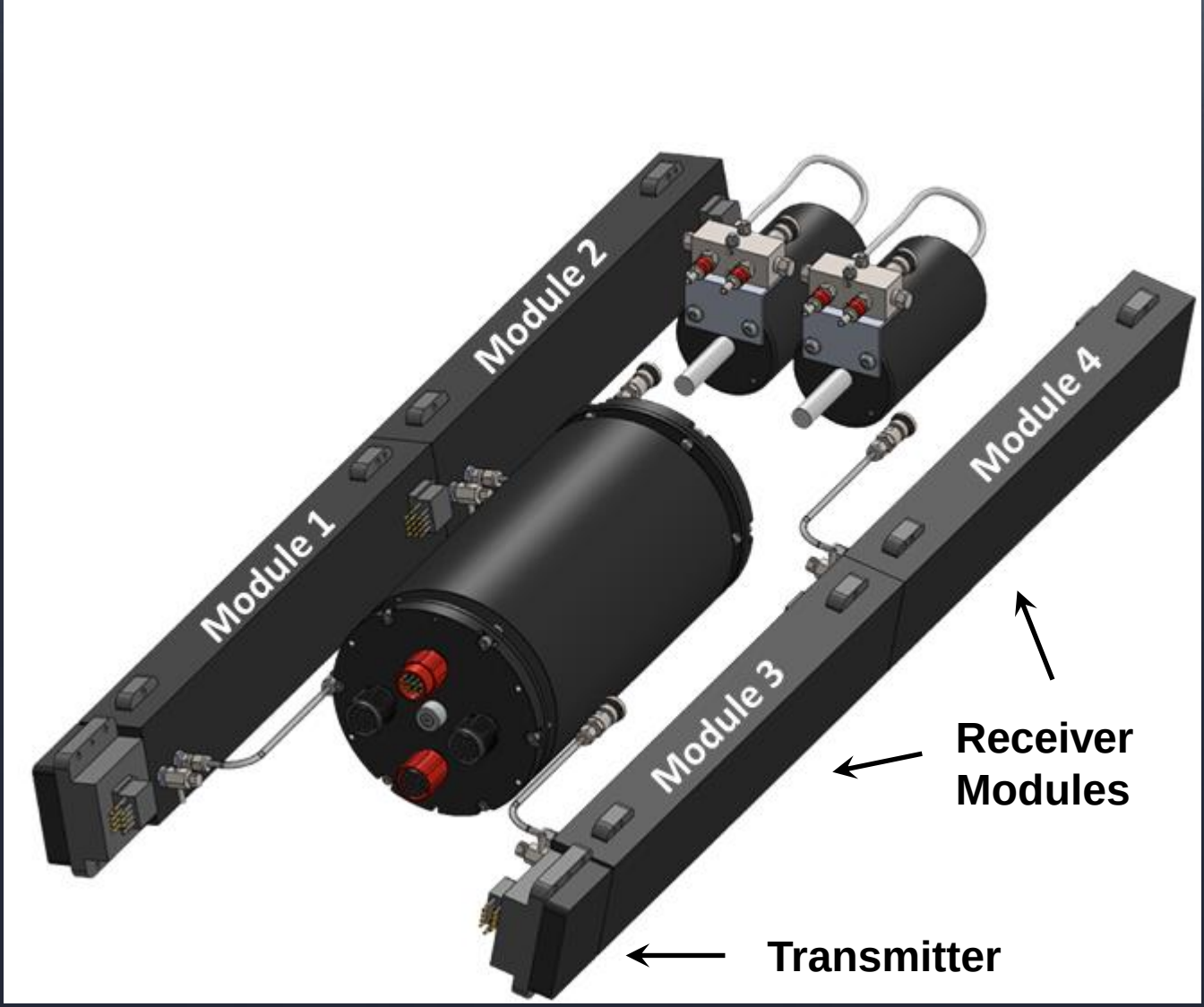
Example AquaPix® Installations



MINSAS Modular Receiver Array



MINSAS 120 Configuration



Area Coverage Rate vs. Array Length

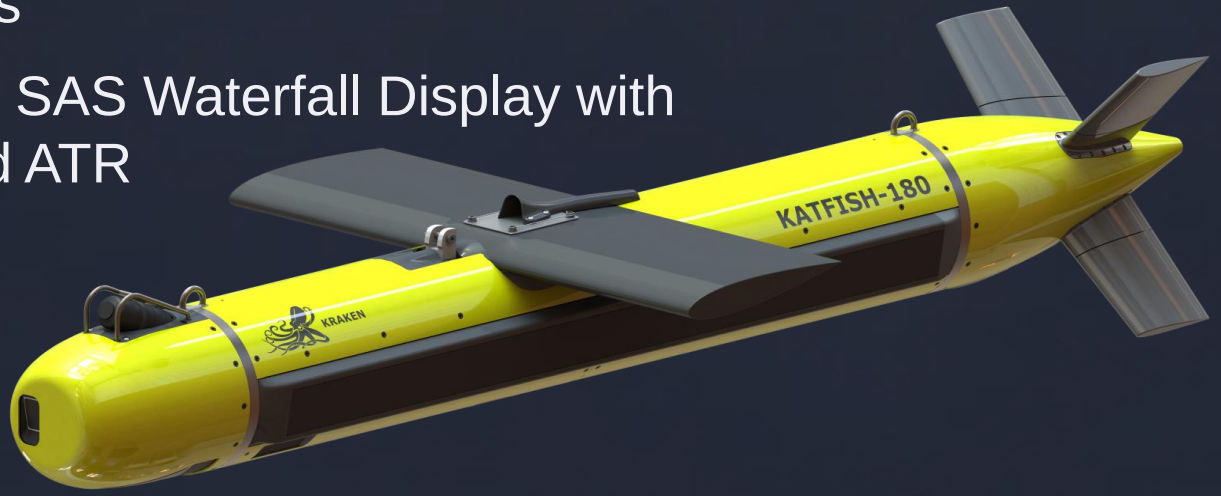
Modules per side	ACR (km^2/h)
1	1
2	2
3	3
4	4

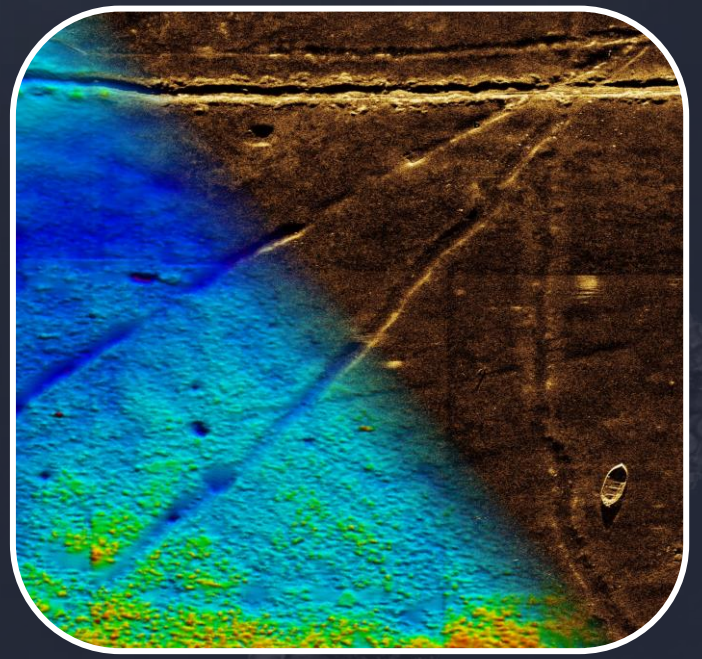
Receiver array is spatially oversampled by 50%

KATFISH™ – High Speed SAS Towfish

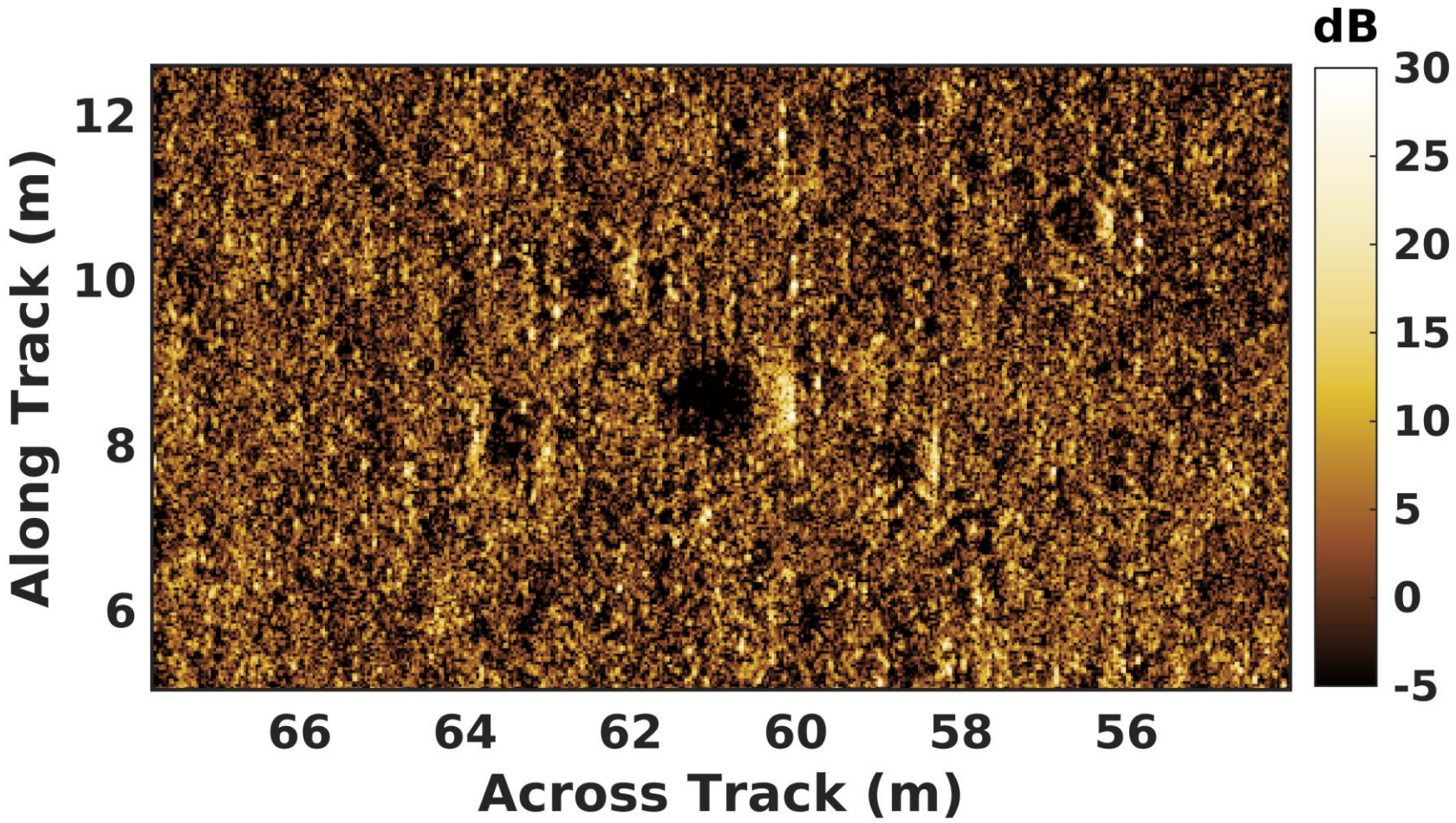
Commercial & Military Certified Versions

- Very High Resolution and ACR
  3.0 x 3.3 cm / 1.9 cm x 2.1 cm
  @ up to 4 km^2 / 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

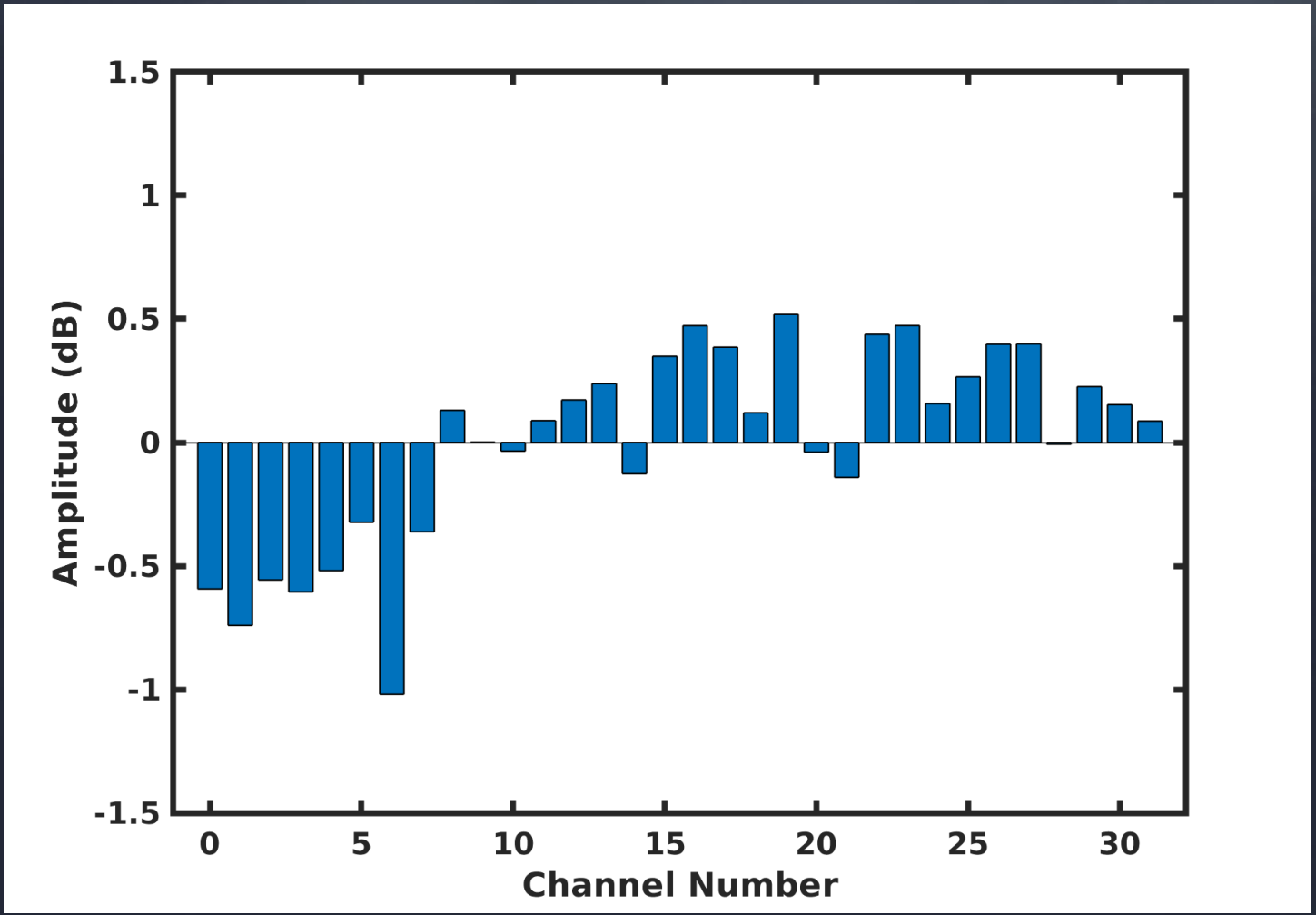




Port SAS Image Before Calibration



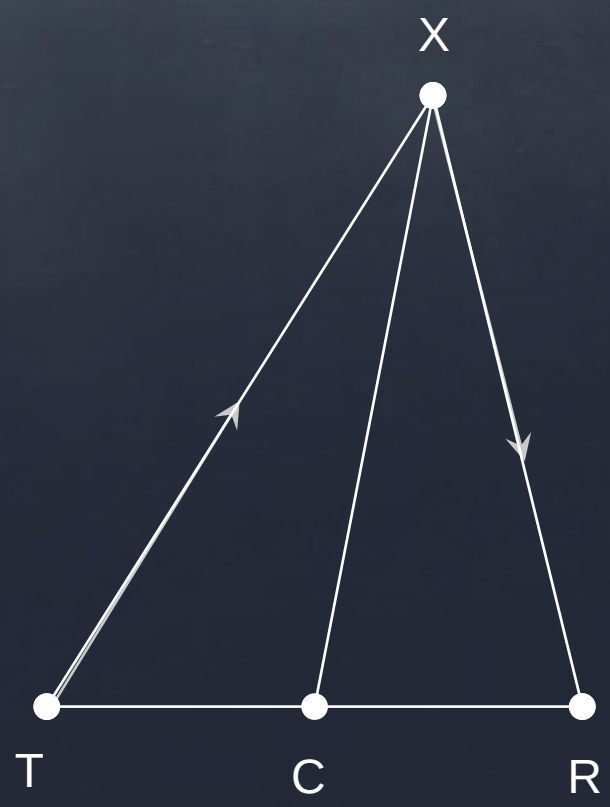
Amplitude Calibration



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

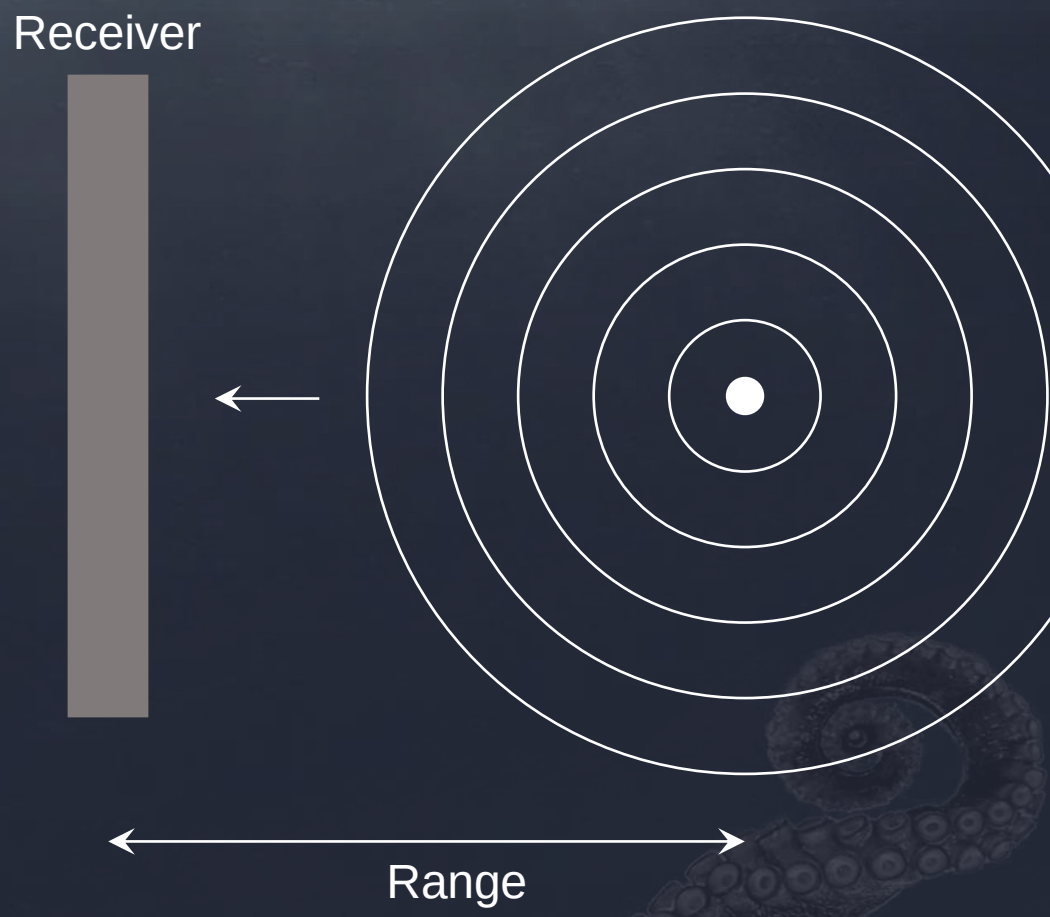
Data Compensation

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

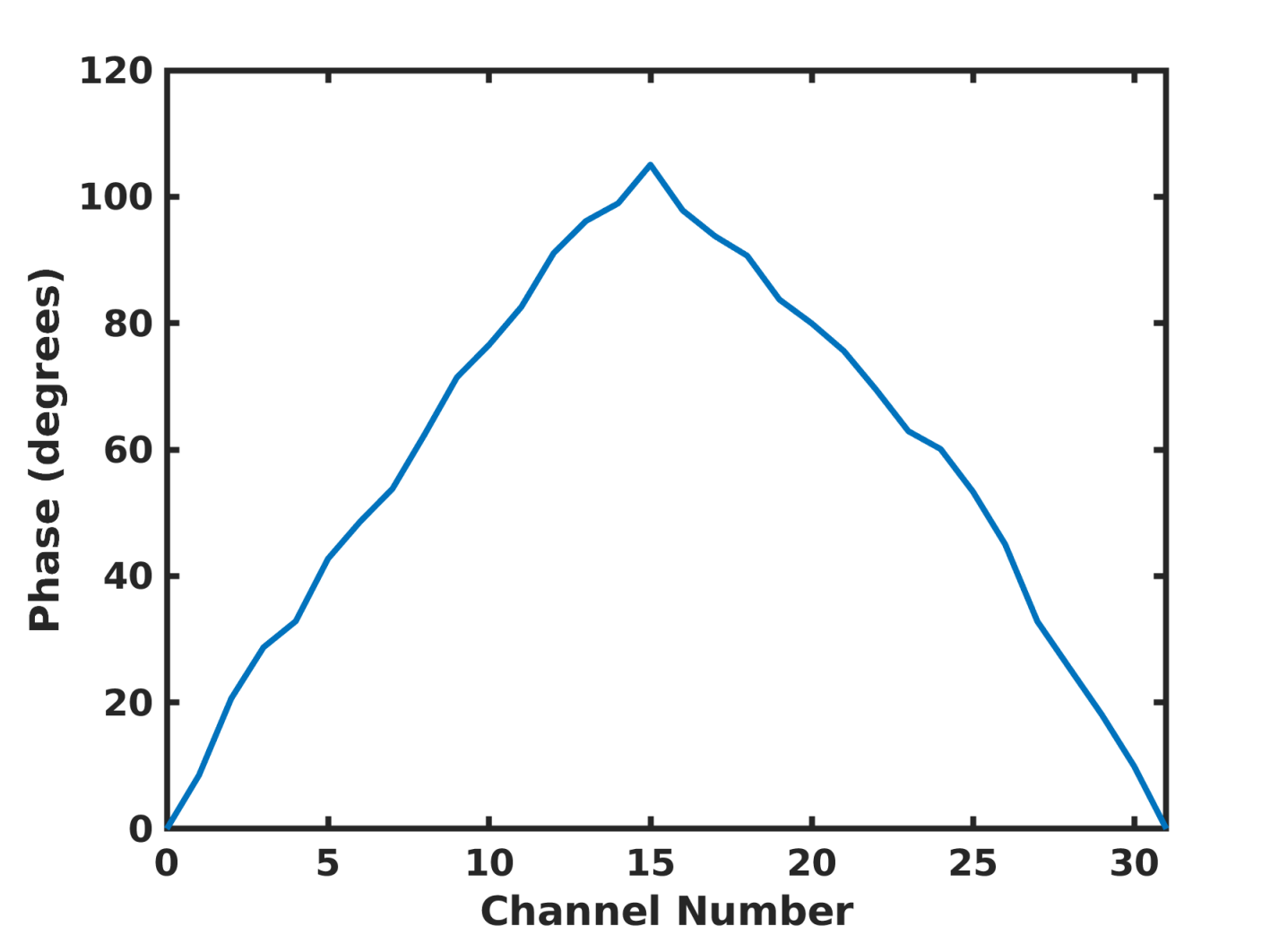


Phase Calibration

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



Phase Calibration

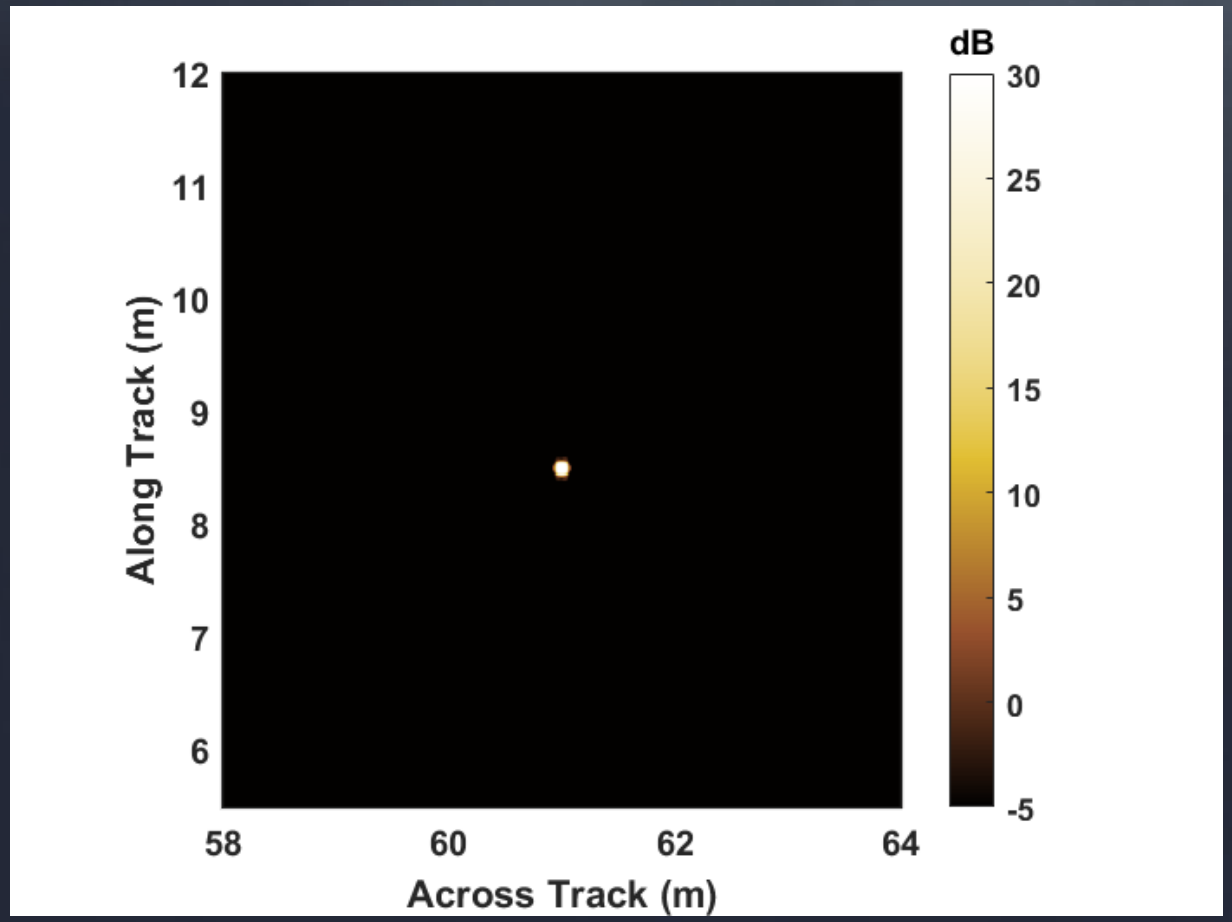


- Positive phase is an inward deflection
- Maximum deflection is 1.3 mm
- Linear slope is a rotation of the module by 1.4°

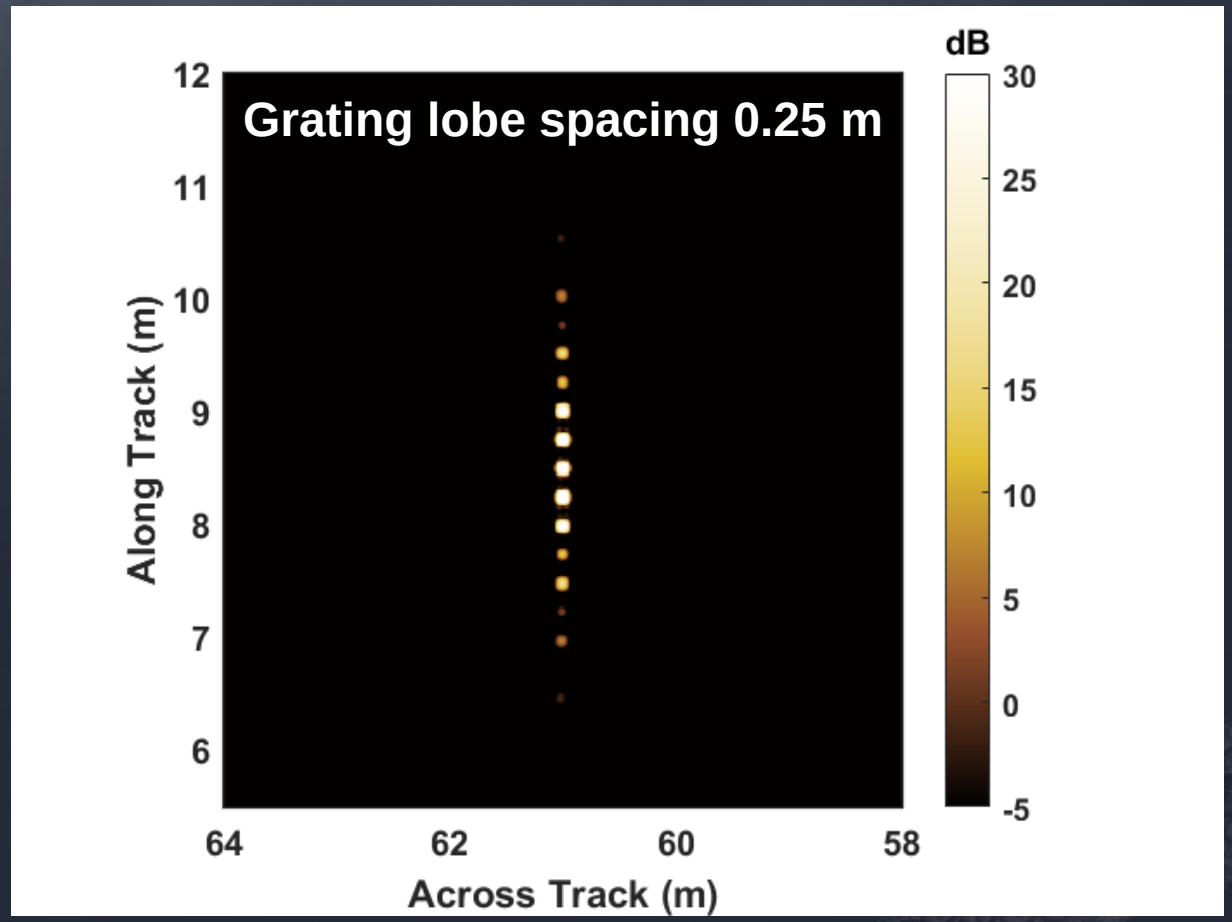
Installation Offset

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

Simulated MINSAS Impulse Response

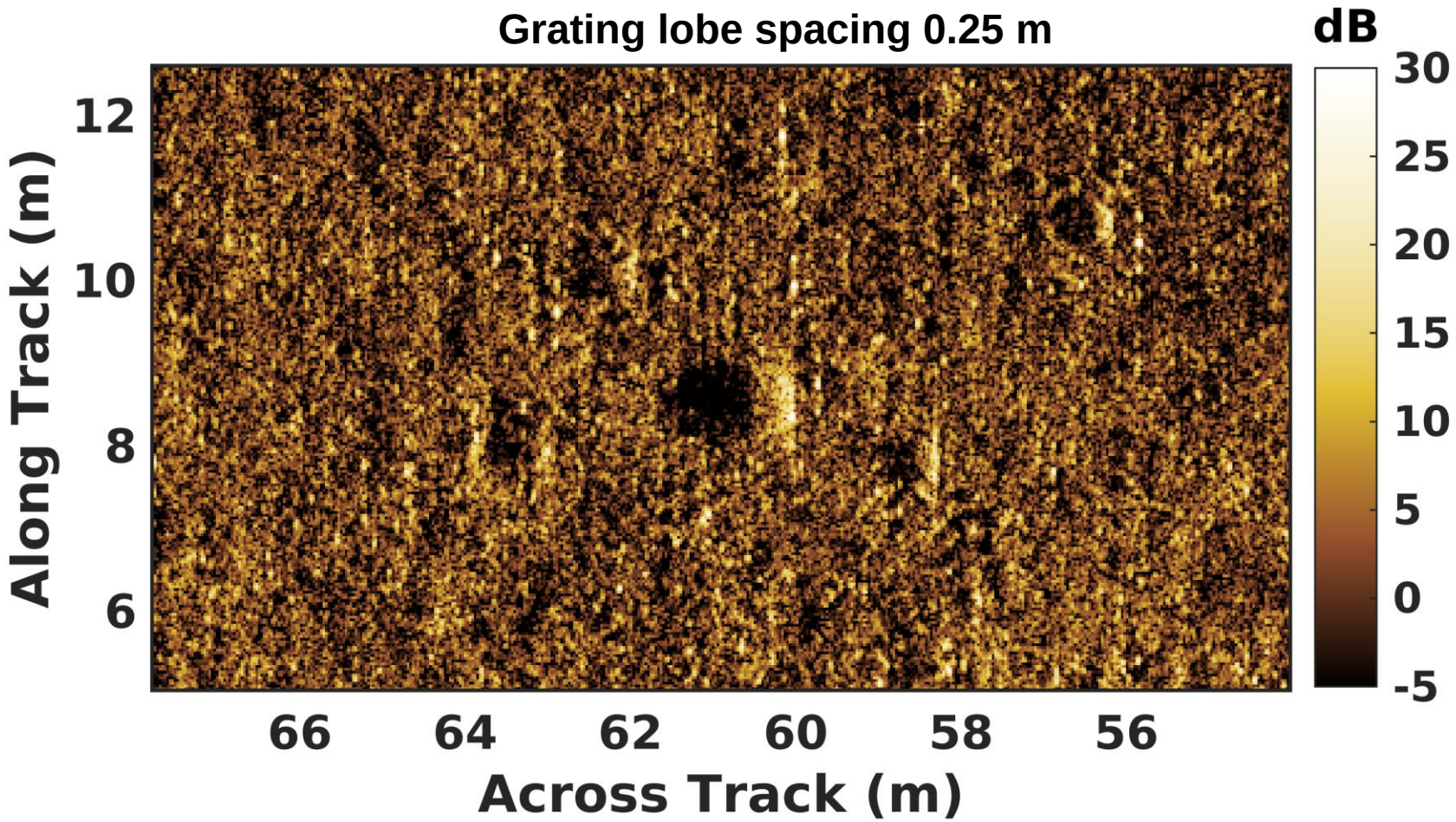


No Phase Error

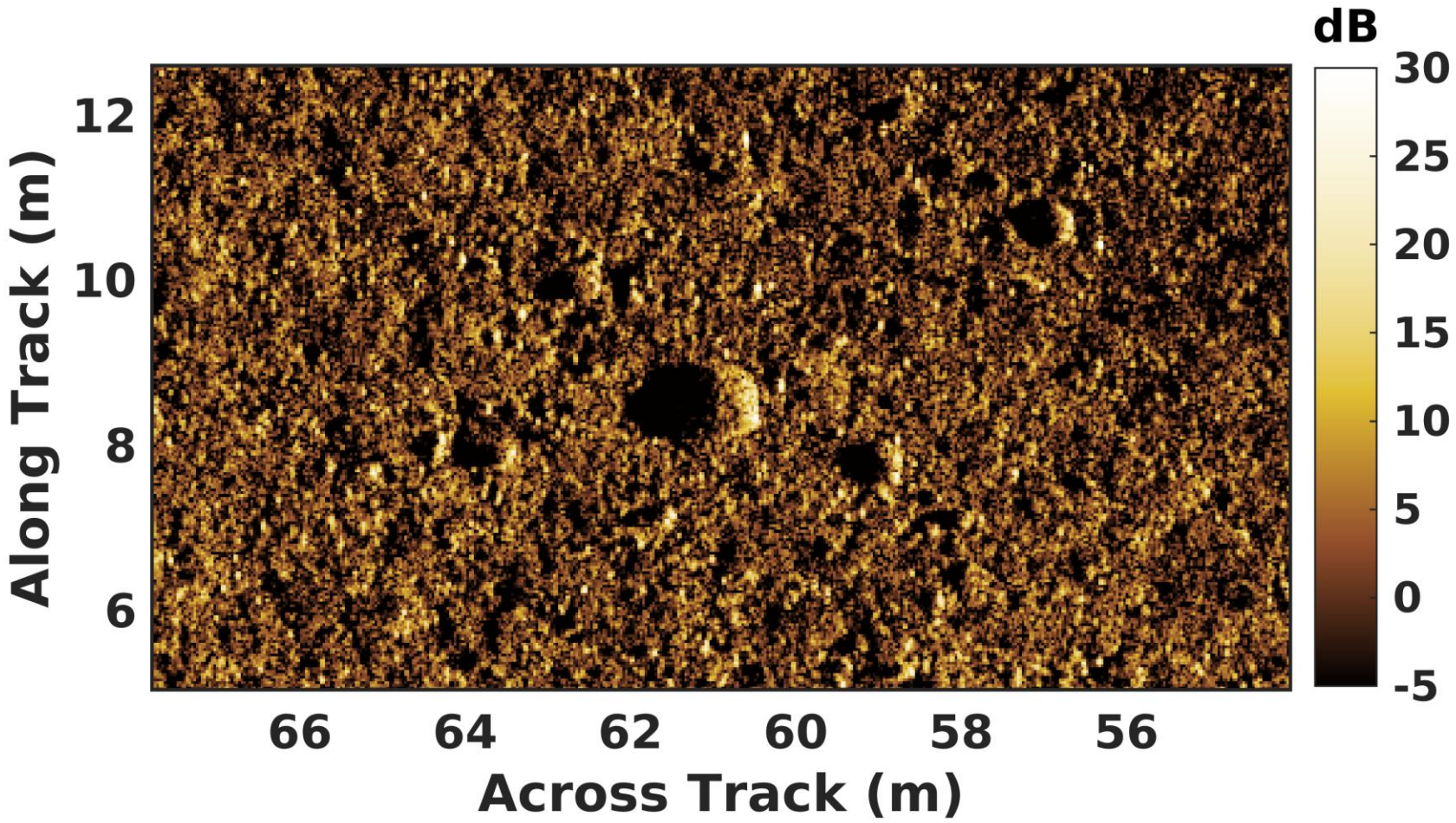


Triangular Phase Error (105° peak)

Port SAS Image Before Calibration



Port SAS Image After Calibration



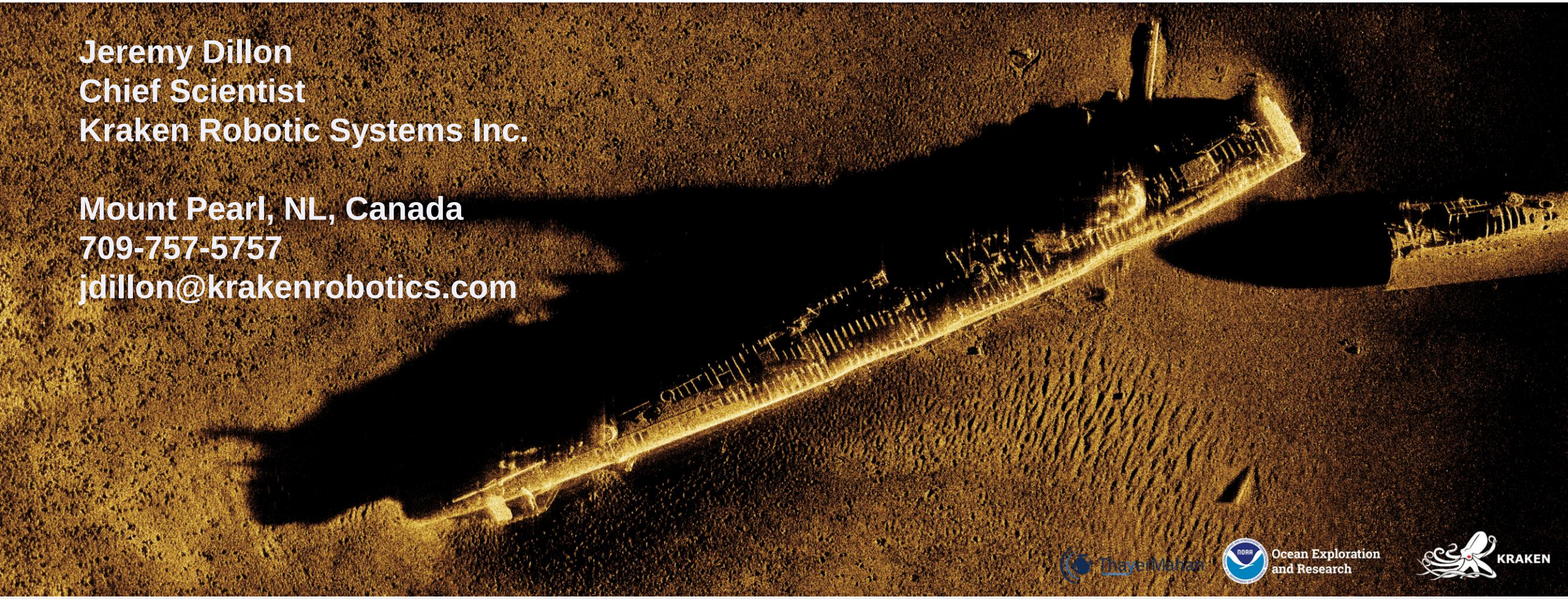
Conclusion

- 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!

Jeremy Dillon
Chief Scientist
Kraken Robotic Systems Inc.

Mount Pearl, NL, Canada
709-757-5757
jdillon@krakenrobotics.com



NOAA Technology Demonstration - July 2019 - USS Bass

https://oceanexplorer.noaa.gov/technology/development-partnerships/ex1904/logs/welcome.html