

# **Multi-Sensor Towbody (MuST) for Detection, Classification, and Geolocation of Underwater Munitions - MR18-B4-5004**

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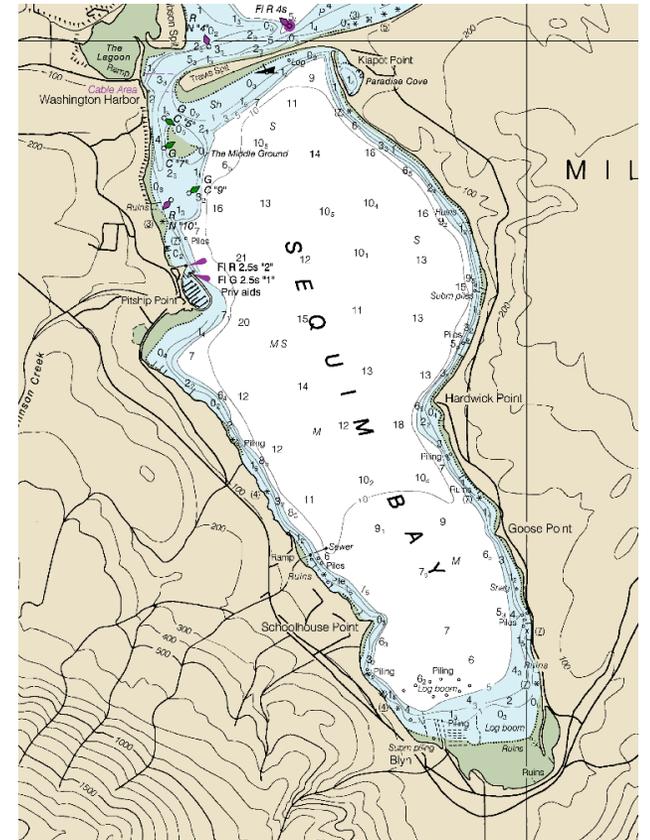
# Technical Approach Overview

- Three year development and demonstration effort:

**YR 1 - Focus on procurement of MacArtney towbody and EdgeTech sonar sub-systems, definition of interfacing hardware and software, and initial construction of the overall system.**

**YR 2 – Calibration of sonars as mounted to towbody.  
Two 7-day engineering tests.**

**YR 3 – Two 7-day operational demonstrations over a munitions field placed in Sequim Bay**



# MuST

- **Technology Focus**

- *Underwater Detection/Classification of buried Munitions using Acoustics*

- **Engineering Test Sites**

- *Engineering tests completed in Lake Washington and Sequim Bay*

- **Engineering Test Objectives**

- *Acquire eBOSS and sidescan data from known Munitions and local environment*

- **Project Progress and Results**

- *Hardware integration completed and fully tested, initial data acquisition complete, 4 days of continuous operation over a wide area of Sequim Bay, currently Geolocation to less than 3 meters*

- **Implementation Outlook**

- *High quality data acquired, signal processing in progress, EdgeTech working on manufacturing technique of panels*



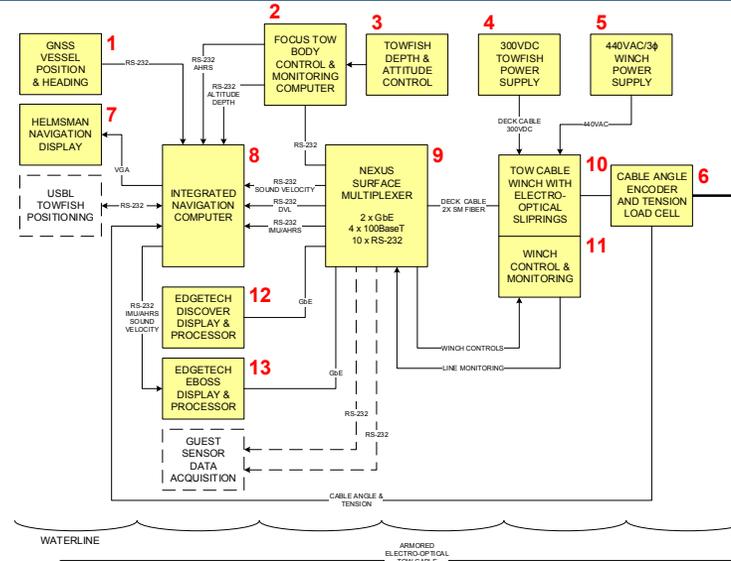
# Demonstration Goals

Performance Objective	Metric	Data Required	Success Criteria
Detection of all munitions of interest	Percent detected/correctly classified of seeded items	<ul style="list-style-type: none"> <li>Location of seeded Items</li> </ul>	$P_c > 0.94$ @ $P_{fa} < 0.1^*$
Location accuracy	Average error and standard deviation in seed item locations	<ul style="list-style-type: none"> <li>Location of seed items from MSL to within 0.25 m.</li> <li>Estimated location from analysis of navigation data</li> </ul>	Navigation-based location error standard deviation < 2 m
Production rate	Number of km <sup>2</sup> of data collection per day	<ul style="list-style-type: none"> <li>Log of field work</li> </ul>	1 km <sup>2</sup> per day

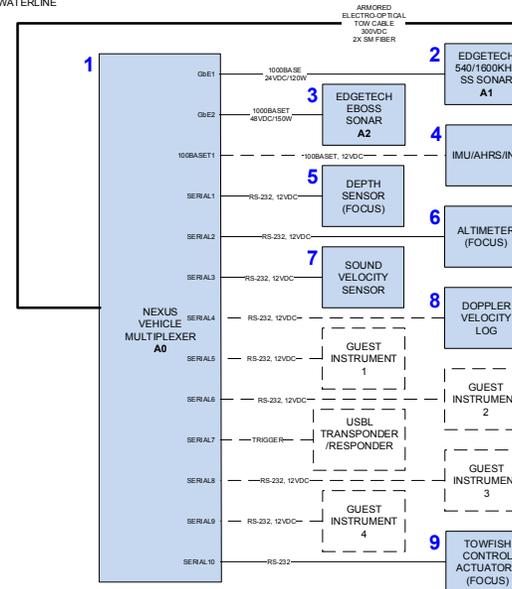
- The assumption is that a seeded field will have on order of 50 munitions and 50 clutter items.  $P_c$  of 0.94 infers 3 missed munitions out of 50. A  $P_{fa}$  of 0.1 implies that 5 of the clutter items are mislabeled as munitions. The performance needed in operational systems might be significantly different than the success criteria given here.

# MuST functional block diagram

Shipboard Equipment



In-water Equipment



# MuST major mechanical components



Ship – 50 ft. long, A-frame or crane (not part of MuST)

In-Water Systems:  
Towbody,  
Acoustic Sensors,  
Guest Sensor Ports

Shipboard Systems:  
Ship Navigation  
Towbody Geo-location,  
Towbody handling,  
Towbody command and control,  
Data Processing

# Technical Progress

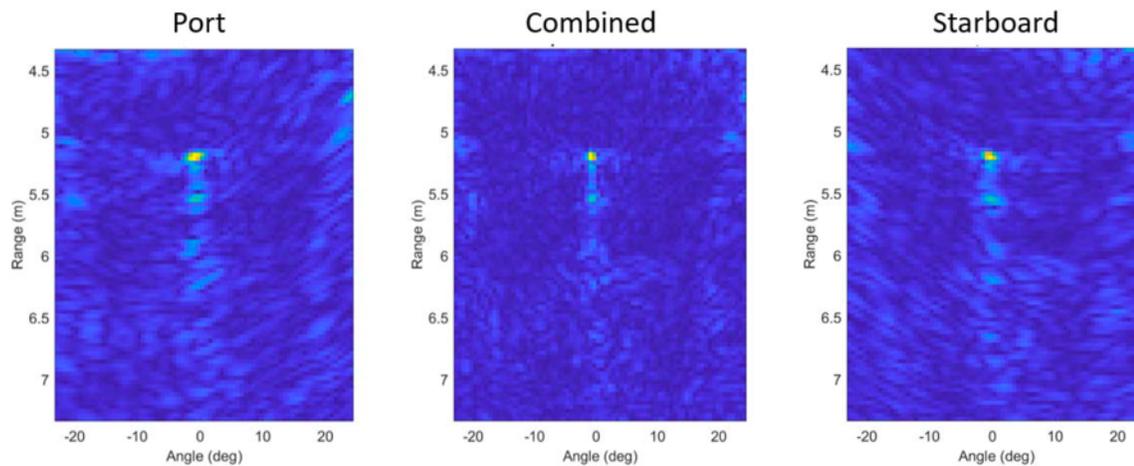
- Delivery of components: Oct. - Dec. 2018
- Delivery of Towbody: January 2019
- Site Acceptance Test of Towbody: Feb 2019
- Integration of all components: Feb. - June 2019
- Initial calibration of eBOSS: April 2019
- Placing Munitions and Clutter in Sequim Bay: July 2019
- Lake Washington Test: August 2019
- Sequim Bay Test: September 2019

# Technical Progress

## Initial calibration of eBOSS:

April 2019

- eBOSS wing mounted in APL calibration facility



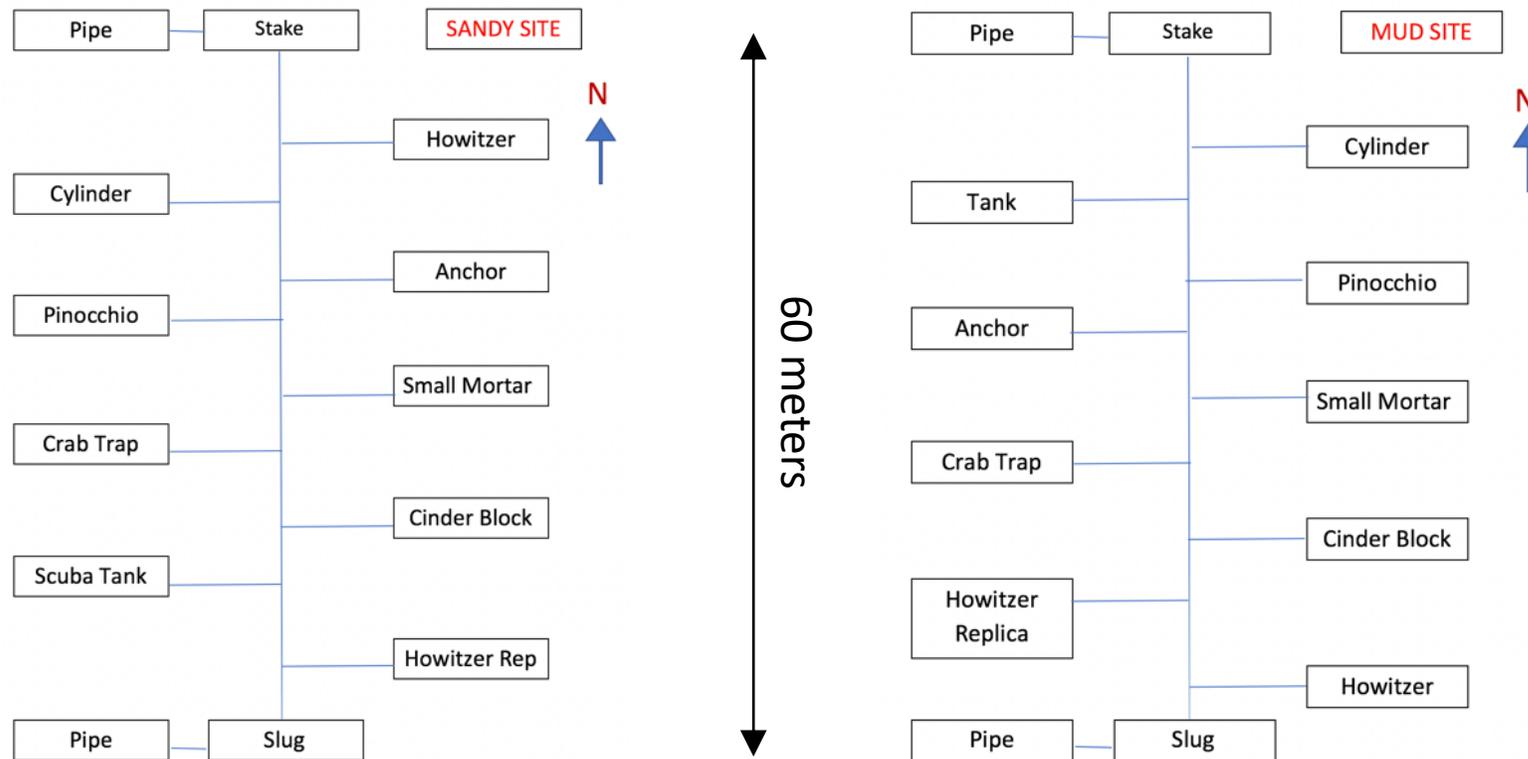
- Images of 30x60 cm Alum. shell taken during calibration.
- eBOSS translated vertically
- Tests real and synthetic aperture algorithms and resolution enhancement of two sources

# Technical Progress

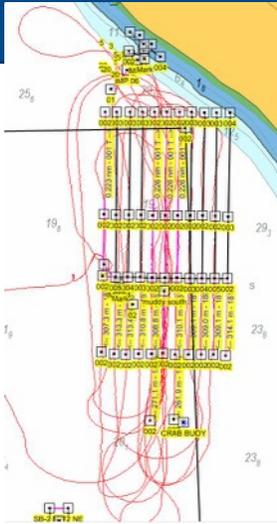
Placing Munitions and Clutter in Sequim Bay:

July 2019

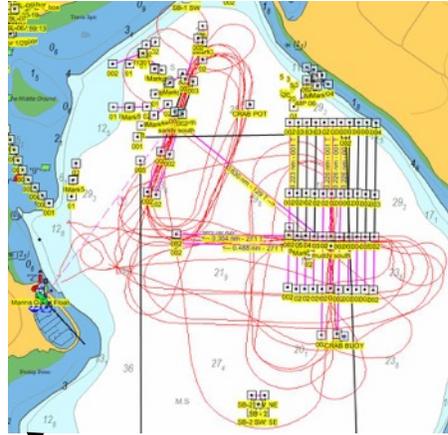
- Joint APL/PNNL four day effort - total of 24 objects in two locations



# Technical Progress



Sept. 9

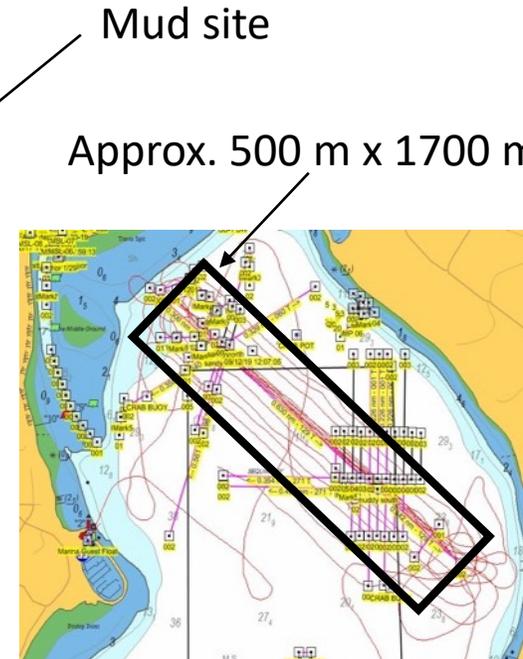


Sept. 10

Sequim Test – GPS ship tracks

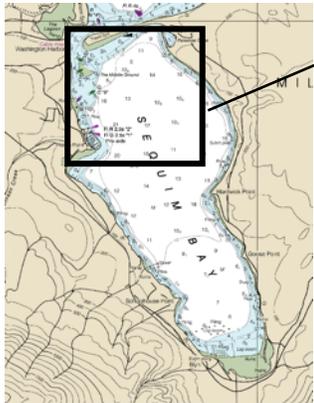


Sept. 11



Sept. 12

Approx. 500 m x 1700 m



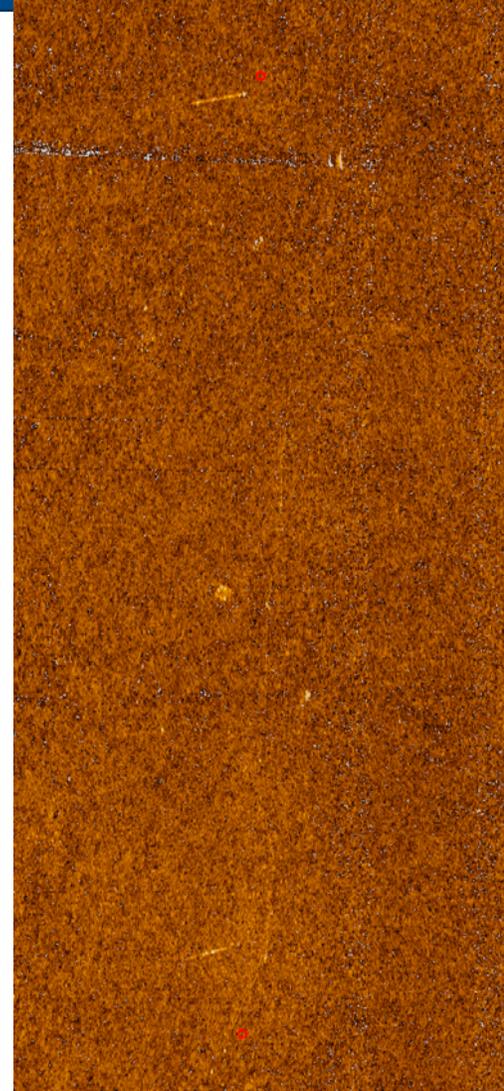
# Sidescan



Broad survey



Mud area



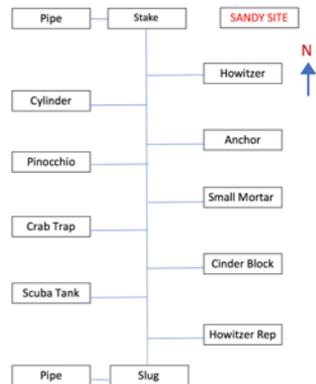
Mud Target Line

# Sidescan & Geolocation

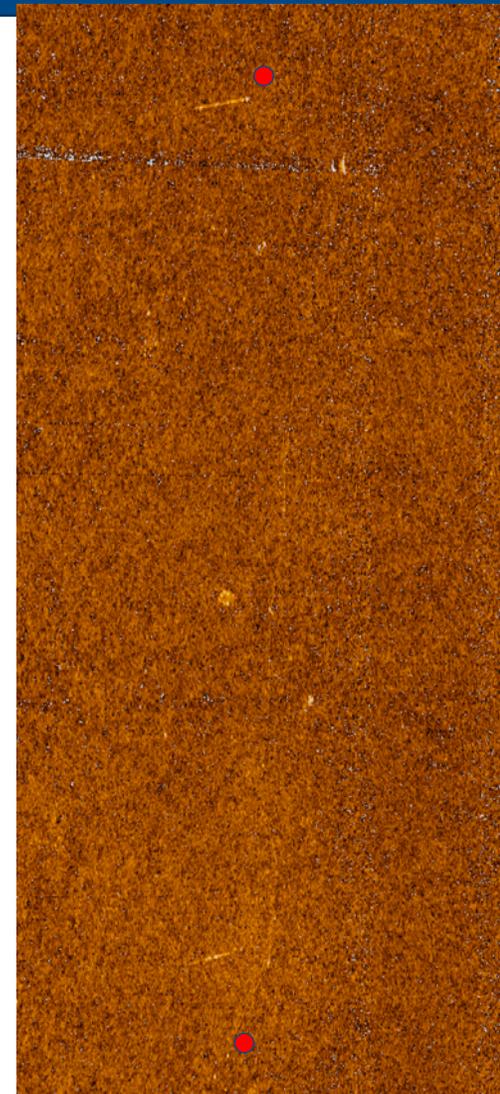
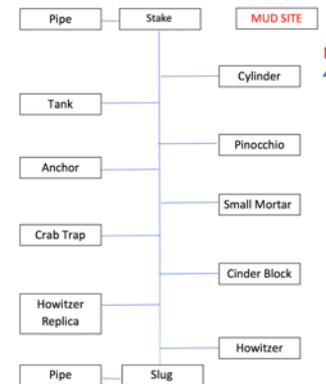


Red dots indicate GPS estimated location of end points of each line  
Of targets made by taut surface lines  
And small boat GPS

Sand  
Target  
Line



Mud  
Target  
Line

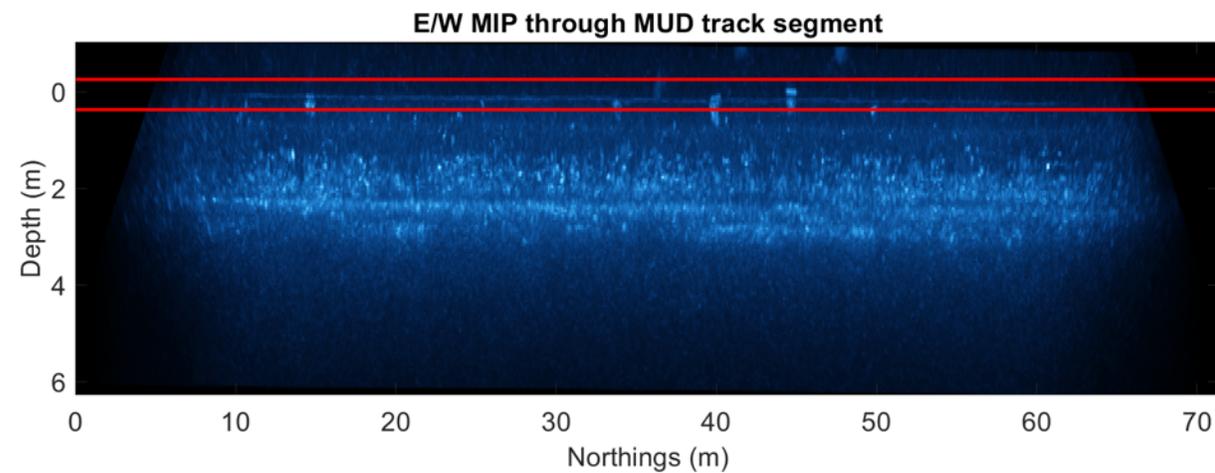
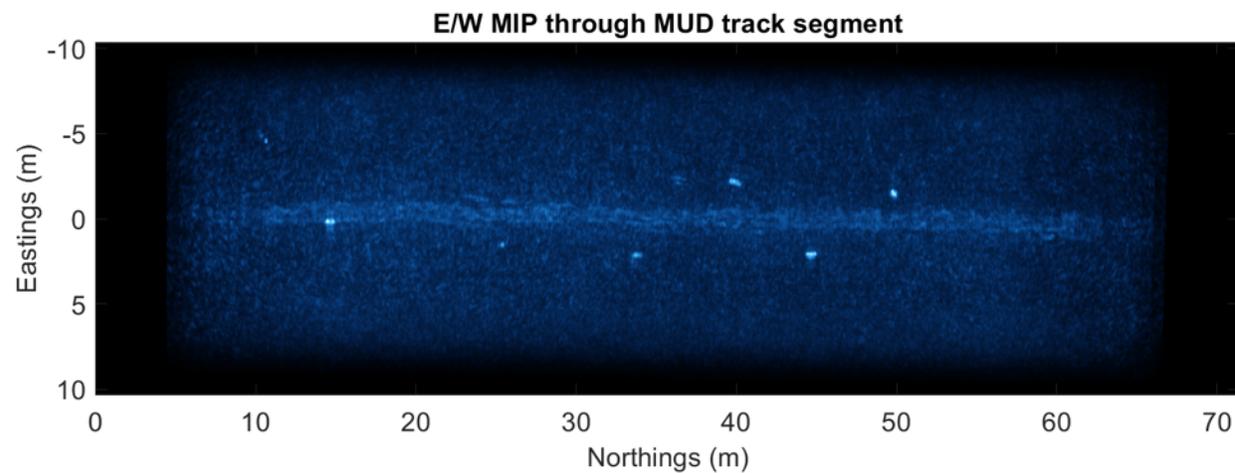


Geolocation by Survey software  
Ship GPS and  
Towbody cable  
Layout is within  
2-3 meters of  
Small boat estimate  
Using taut surface  
lines

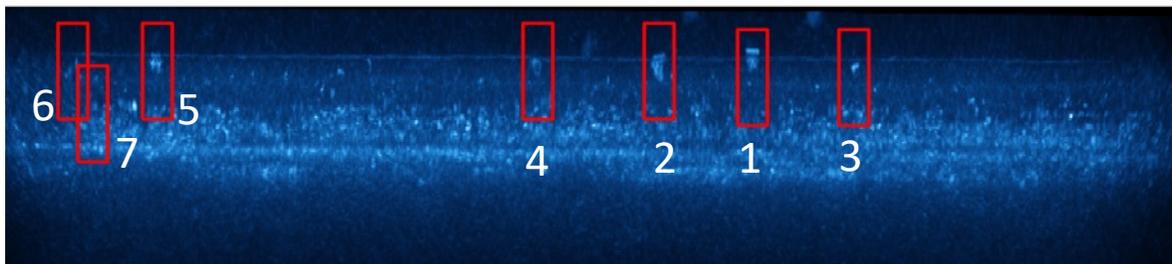
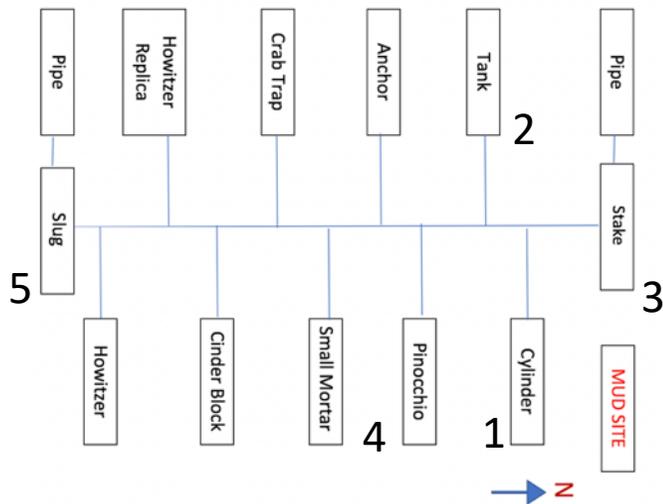
# eBOSS MUD SITE

- 2000 pings (some targets not included)
- 120 deg. integration angle (real ap.)
- 90 deg. integration angle (synthetic ap.)
- Neptune configuration (L/R alternating)
- Fast Factorized Back Projection (FFBP) imaging
- 5cm voxels (under-sampled for memory restrictions)
  - Future update will reduce size of voxel and make complex

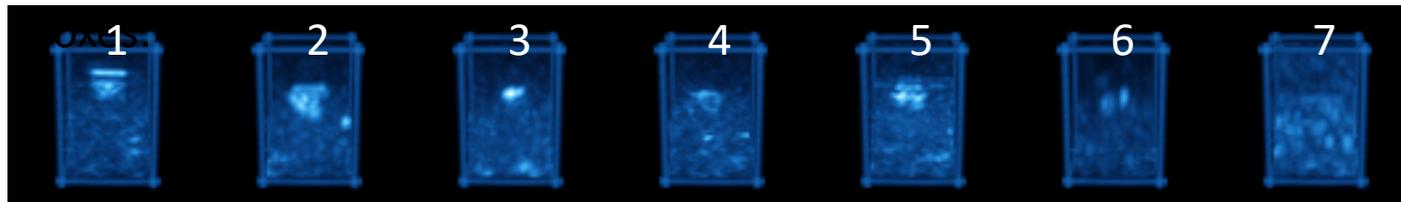
# MIPS



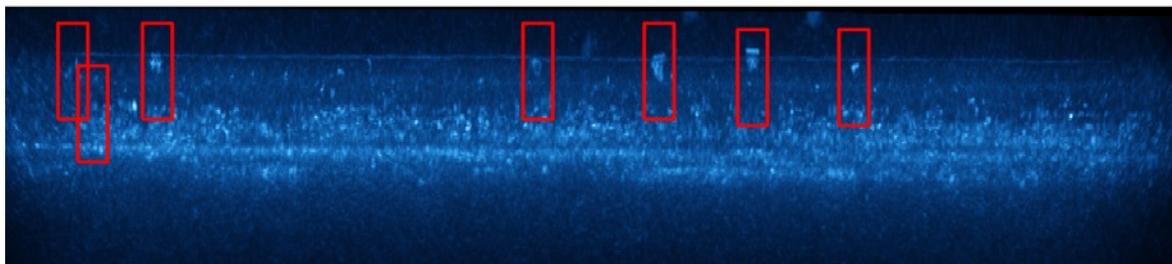
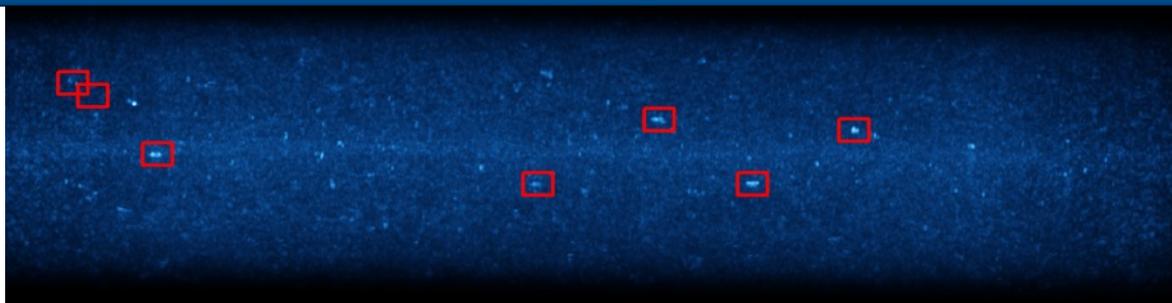
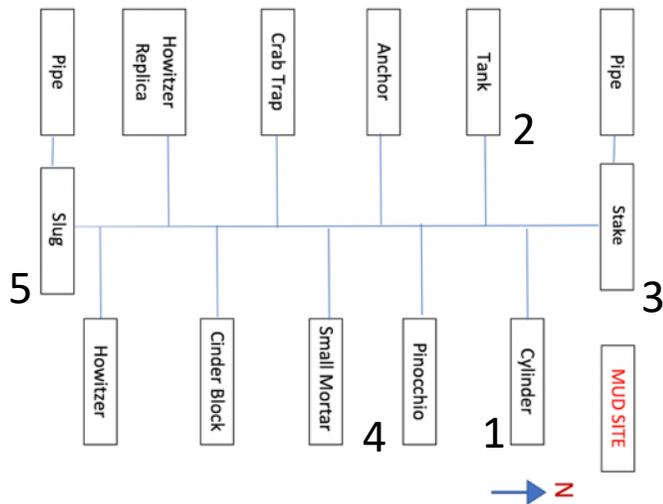
# 3D Target ROI's



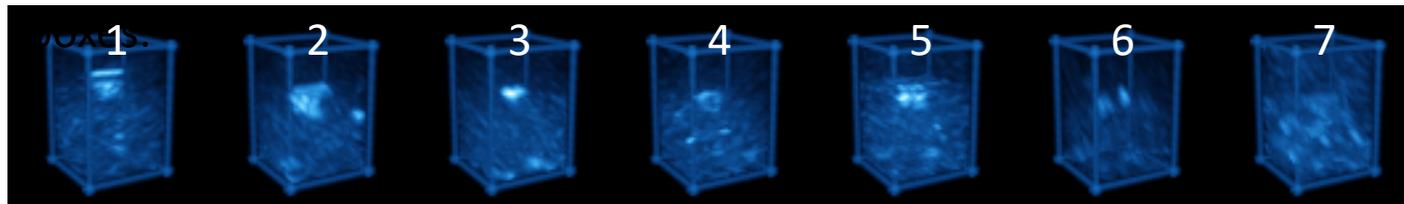
1.5 x 1.5 x 2.25 m. ROI



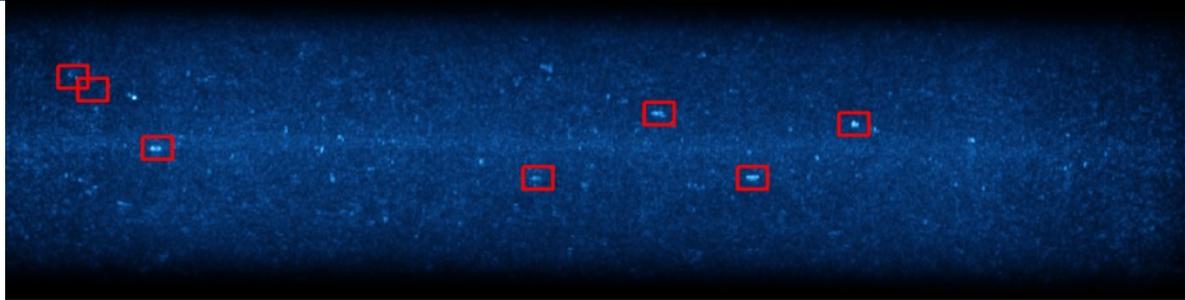
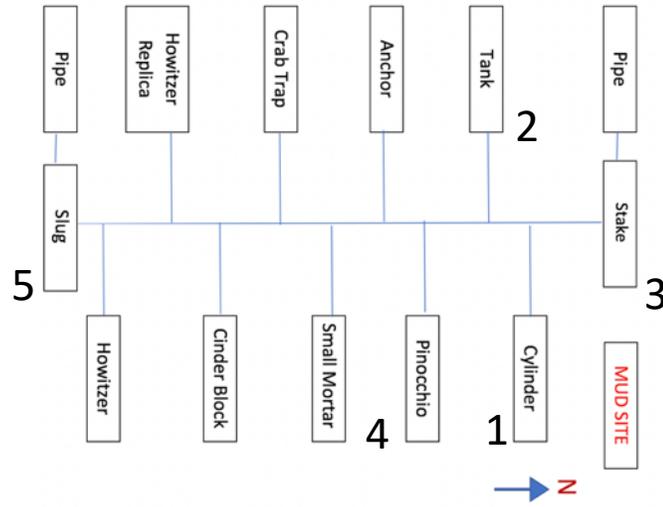
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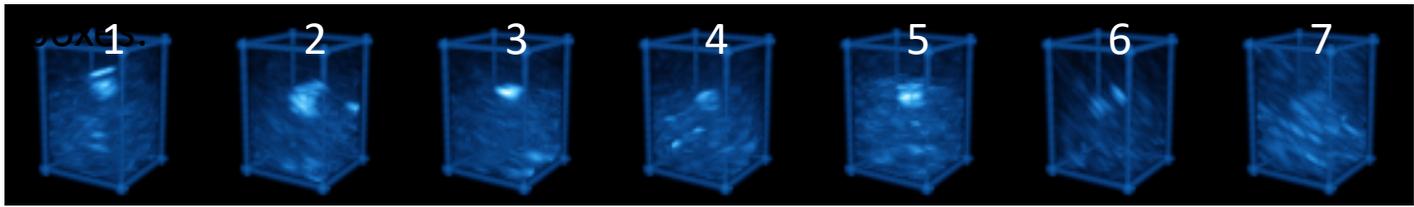
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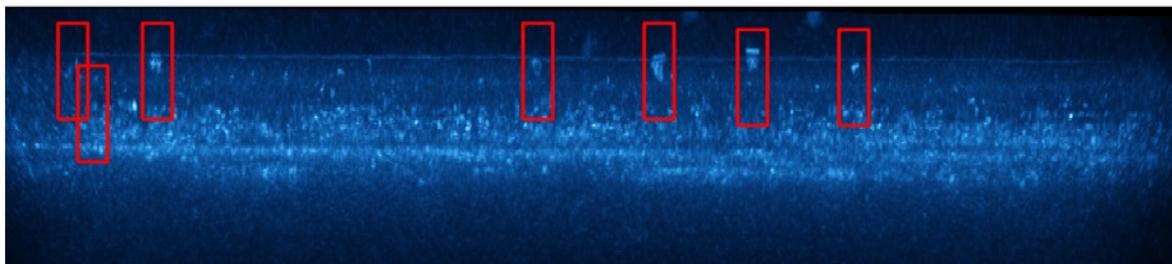
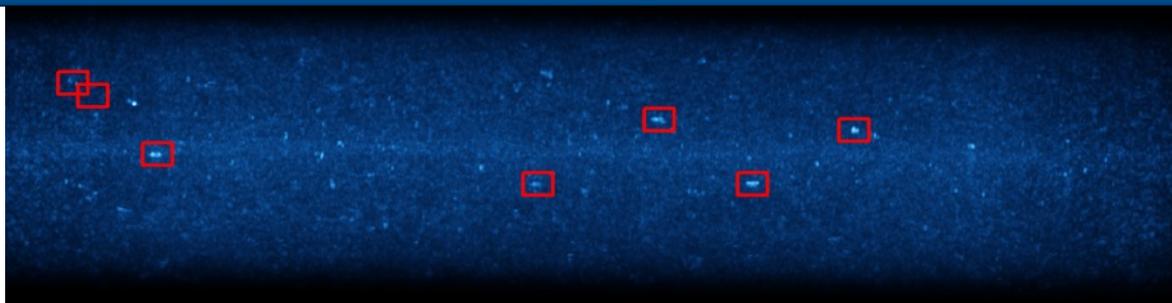
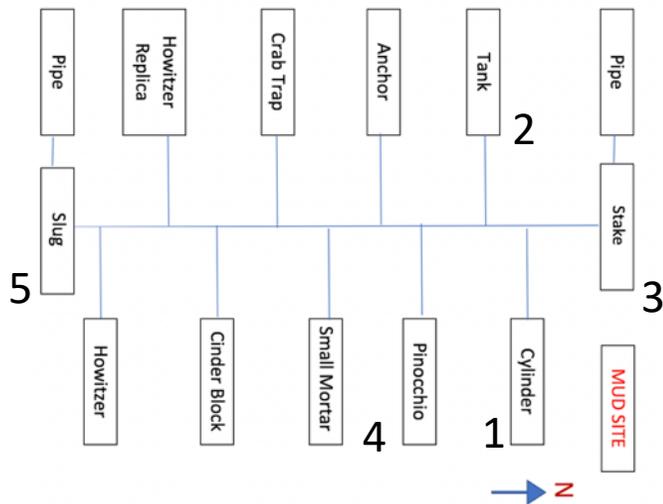
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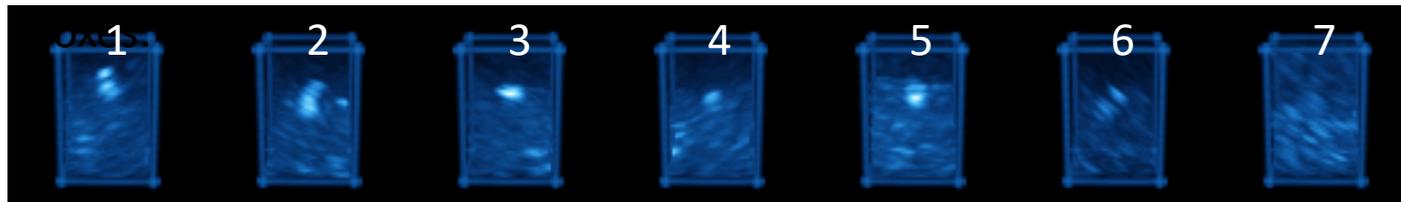
1.5 x 1.5 x 2.25 m. ROI



# 3D Target ROI's



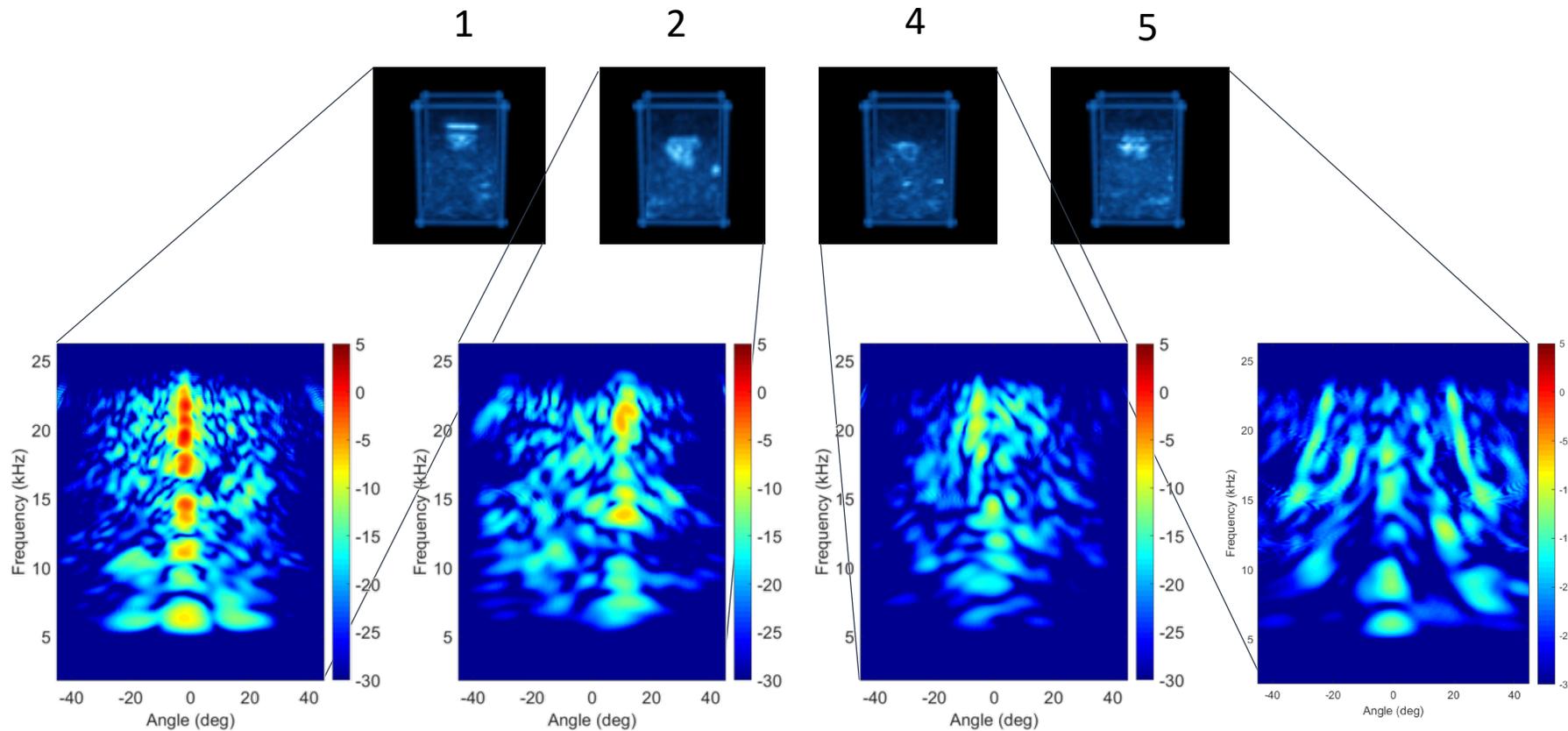
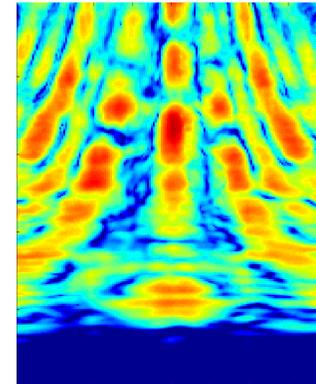
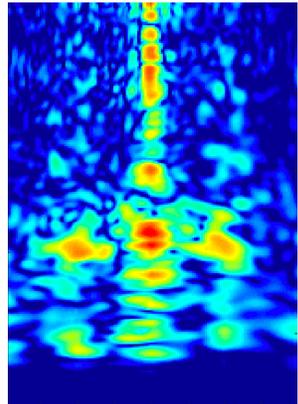
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# Acoustic Color extraction:

Al Pipe BAYEX14

Cement Block Clutterex 17



# SUMMARY

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- *Acquired eBOSS and sidescan data from known Munitions and local environment*
- *Hardware integration completed and fully tested, initial data acquisition complete, 4 days of continuous operation over a wide area of Sequim Bay, currently Geolocation to within 3 meters*
- *High quality data acquired, signal processing in progress*



# QUESTIONS?



# MuST in Action

<https://www.youtube.com/watch?v=4UKmavb1TPY>

