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Platforms for Underwater and Near-Shore Munitions Surveys

November 2, 2017

SERDP DOD ▪ EPA ▪ DOE | ESTCP

Welcome and Introductions

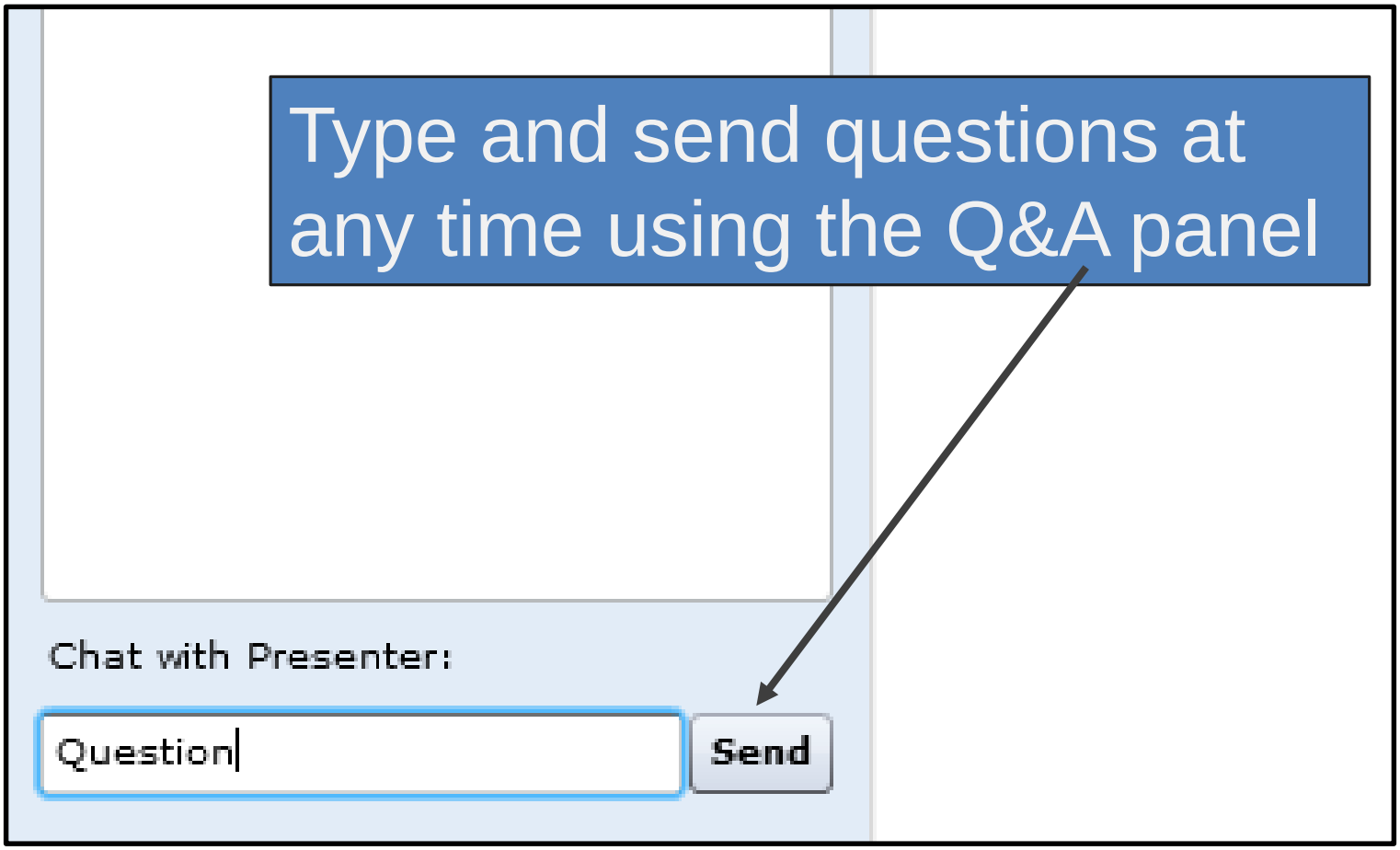
Jennifer Nyman, Ph.D., P.E.
Webinar Facilitator

SERDP DOD ▪ EPA ▪ DOE | ESTCP

Webinar Agenda

- **Webinar Logistics** (5 minutes)
  Dr. Jennifer Nyman, Geosyntec Consultants
- **Overview of SERDP and ESTCP** (5 minutes)
  Dr. Herb Nelson, SERDP and ESTCP
- **Updating the Marine Towed Array for Advanced Geophysical Classification** (25 minutes + Q&A)
  Dr. Dan Steinhurst, Nova Research, Inc.
- **Near-Shore UXO Arrays Deployed from Unmanned Platforms** (25 minutes + Q&A)
  Dr. Greg Schultz, White River Technologies
- **Final Q&A session**

How to Ask Questions



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  - Click the mute/connect button
  - Wait 3-5 seconds
  - Click the mute/connect button again
  - If delays continue, call into the conference line
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SERDP and ESTCP Overview

Herb Nelson, Ph.D.
Munitions Response Program Manager

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SERDP

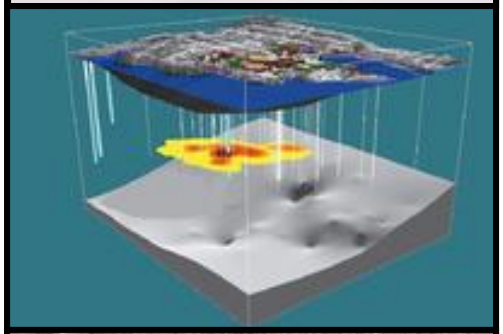
- Strategic Environmental Research and Development Program
- Established by Congress in FY 1991
  - DoD, DOE and EPA partnership
- SERDP is a requirements driven program which identifies high-priority environmental science and technology investment opportunities that address DoD requirements
  - Advanced technology development to address near term needs
  - Fundamental research to impact real world environmental management

ESTCP

- Environmental Security Technology Certification Program
- Demonstrate innovative cost-effective environmental and energy technologies
  - Capitalize on past investments
  - Transition technology out of the lab
- Promote implementation
  - Facilitate regulatory acceptance

Program Areas

1. Energy and Water
2. Environmental Restoration
3. Munitions Response
4. Resource Conservation and Resiliency
5. Weapons Systems and Platforms


Munition Response

- Munitions on land
  - Classification
- Munitions underwater
  - Wide area and detailed surveys
  - Cost-effective recovery and disposal
  - Characteristics of munitions underwater, their environment and mobility

SERDP and ESTCP Webinar Series

Date	Topic
November 16, 2017	Building Envelope Technologies
December 7, 2017	Management of Novel Hawaiian Ecosystems

- *Webinars will continue every new weeks in 2018*

For upcoming webinars, please visit

http://serdp-estcp.org/Tools-and-Training/Webinar-Series

SERDP • ESTCP SYMPOSIUM

2017 | Enhancing DoD's Mission Effectiveness

A three-day symposium showcasing the latest technologies that enhance DoD's mission through improved environmental and energy performance

- November 28 - November 30, 2017
- Washington Hilton Hotel
  1919 Connecticut Avenue, NW
  Washington, DC 20009
- ***Program agenda available online and registration is still open…***

Updating the Marine Towed Array for Advanced Geophysical Classification

Dr. Dan Steinhurst

Nova Research, Inc.

SERDP DOD • EPA • DOE | ESTCP

Agenda

- Project motivation
- Marine Towed Array (MTA)
- Sensors for unexploded ordnance (UXO) classification
- Array design and testing
- Modeling results
- Conclusions

Project Motivation

- UXO
  - Large number of underwater sites
  - Present a significant human health risk
- Systematic detection and classification limited
  - Unfriendly survey conditions
  - Technology gaps, as compared to land surveys
- Acoustic systems
  - Significant standoff range
  - Limited capability against buried targets
  - Limited capability in shallow water (3 - 5 m)
- Adaptation of land-based UXO technology

UXO in the Underwater Environment

Photo: ESTCP MR-0324 (Bahia Salinas del Sur Final Report)

Marine Towed Array

- Towed “flying wing” design
  - Development funded by SERDP/ESTCP
  - Dual-mode sensor array
    - Total-field Cesium-vapor magnetometers
    - Electromagnetic induction (EMI) sensor array
- Successfully demonstrated under a range of conditions
- 75 lane-km per day coverage with magnetometers

Marine Towed Array

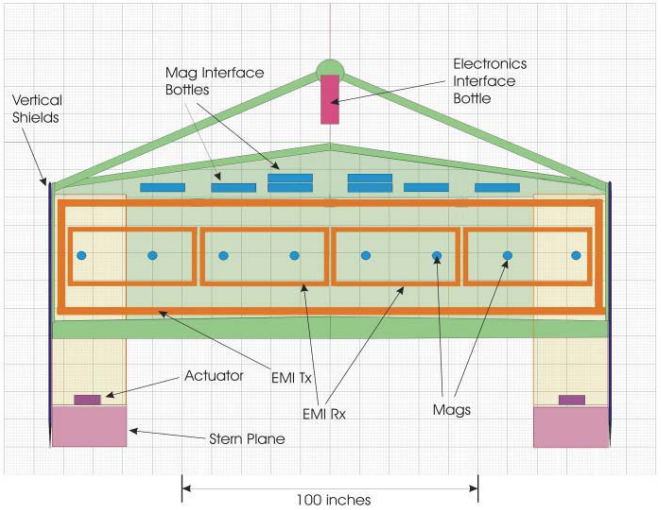


Photo: ESTCP MR-0324 Reports

Sensors for UXO Classification

- Total-field magnetometry
  - Provides effective size and position
  - Little classification ability
- EMI
  - Advanced systems capable of determining
    - Position, depth, size, wall thickness, and shape
  - Robustly support UXO/clutter classification
  - Success demonstrated for land applications

Capability of Advanced Geophysical Classification

Munition

Suspected Munition

Munition Fragment

Debris

Photos: NRL, for ITRC GCMR-1 Fact Sheet

Advanced Geophysical Classification (AGC) Sensor Systems




Photos: ESTCP, URS, USACE

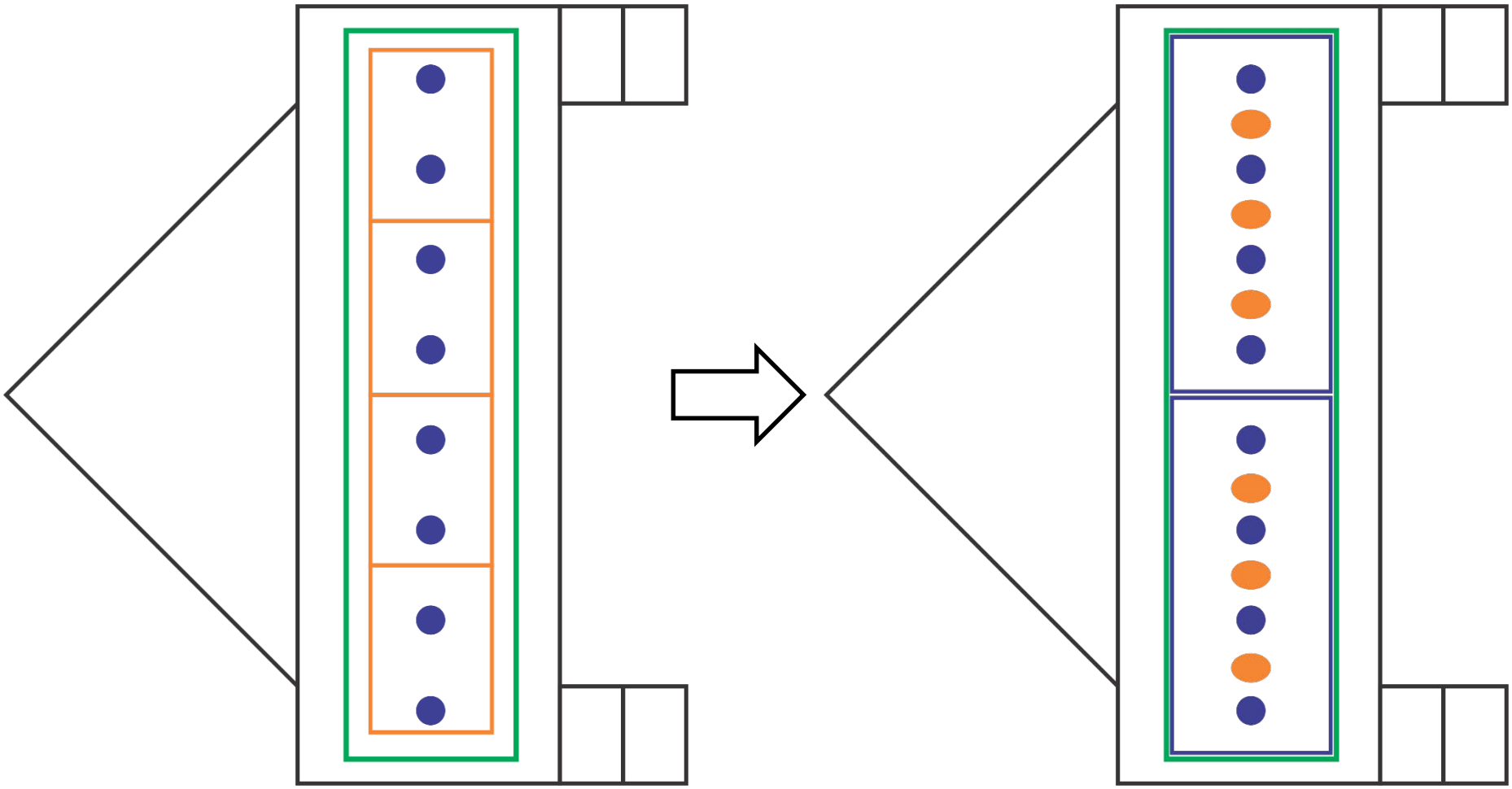
EMI Array Upgrade

- Original array
  - Detection-only electronics
  - Low resolution
    - Four 0.5 m x 1.0 m receiver coils
  - Mechanical and electrical issues
- Updated design
  - AGC-level electronics
  - Multi-static data collection

EMI Array Schematic

Original Configuration

Proposed Configuration



Mini Marine Towed Array

Half-Scale Model

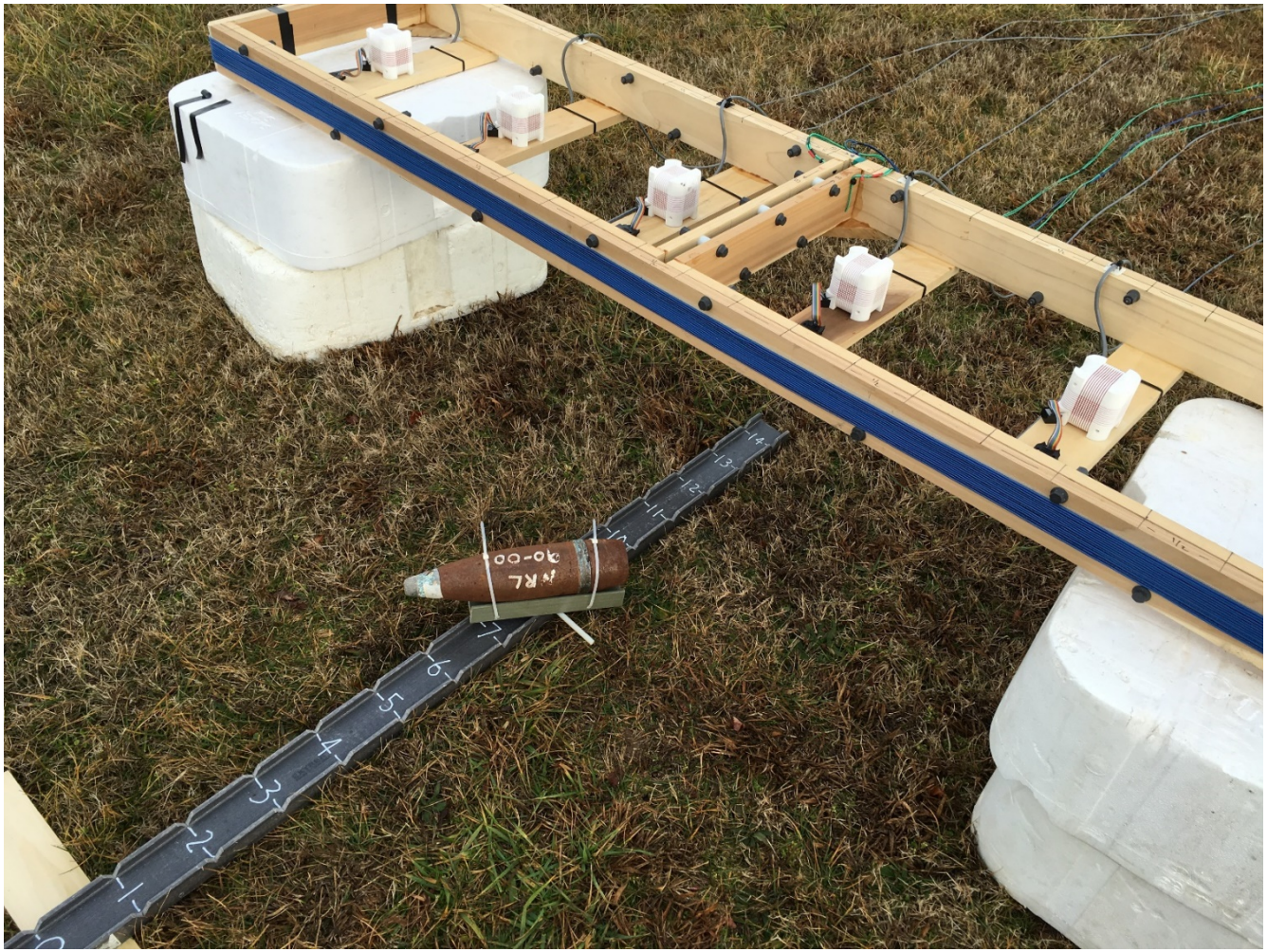
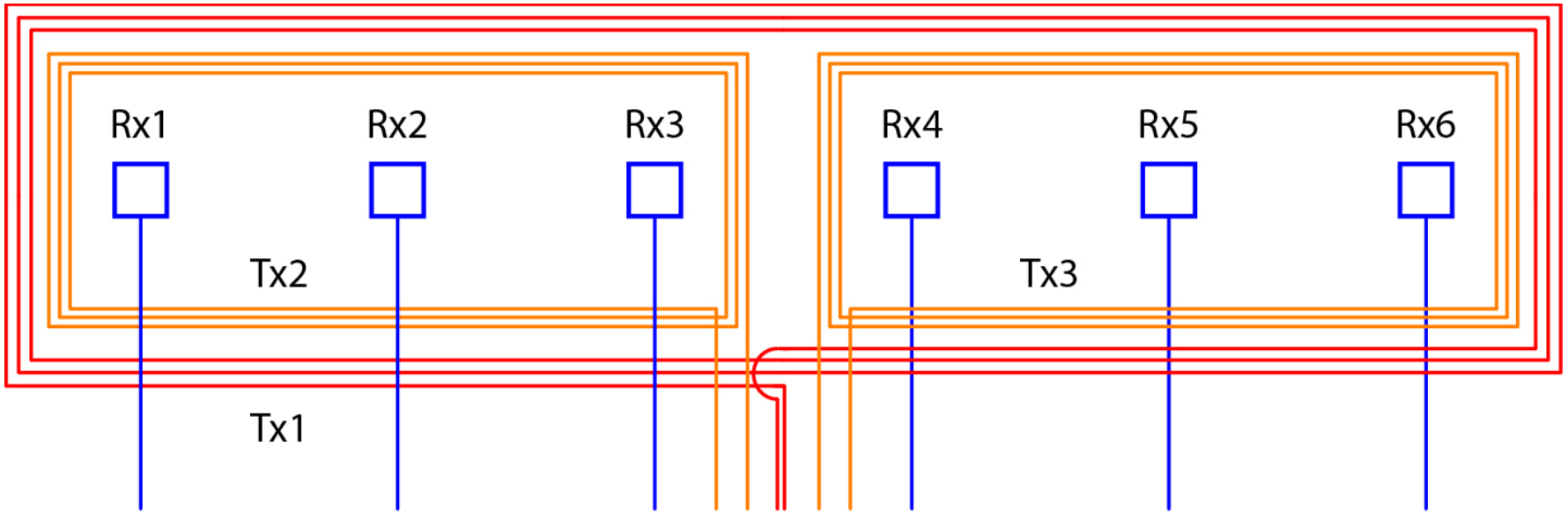


Photo: Leidos

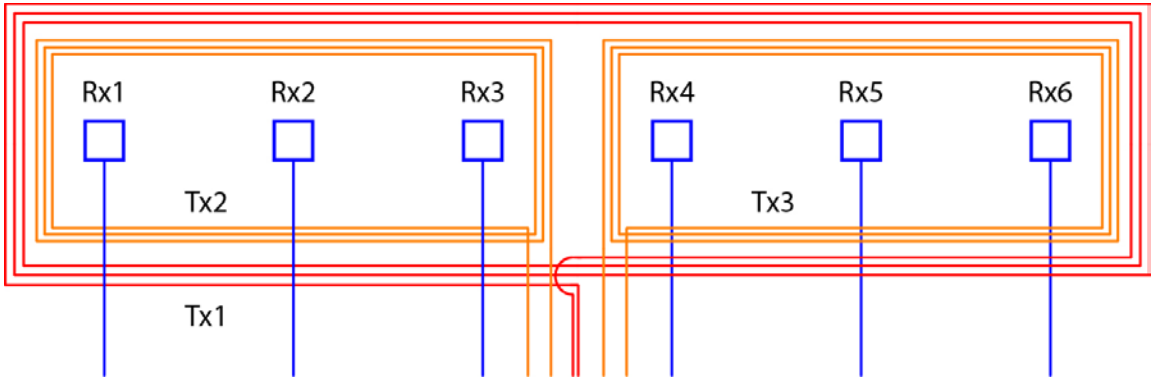
Mini Marine Towed Array Design

- ½ scale, 3 Tx loops
- 6 triaxial Rx cubes



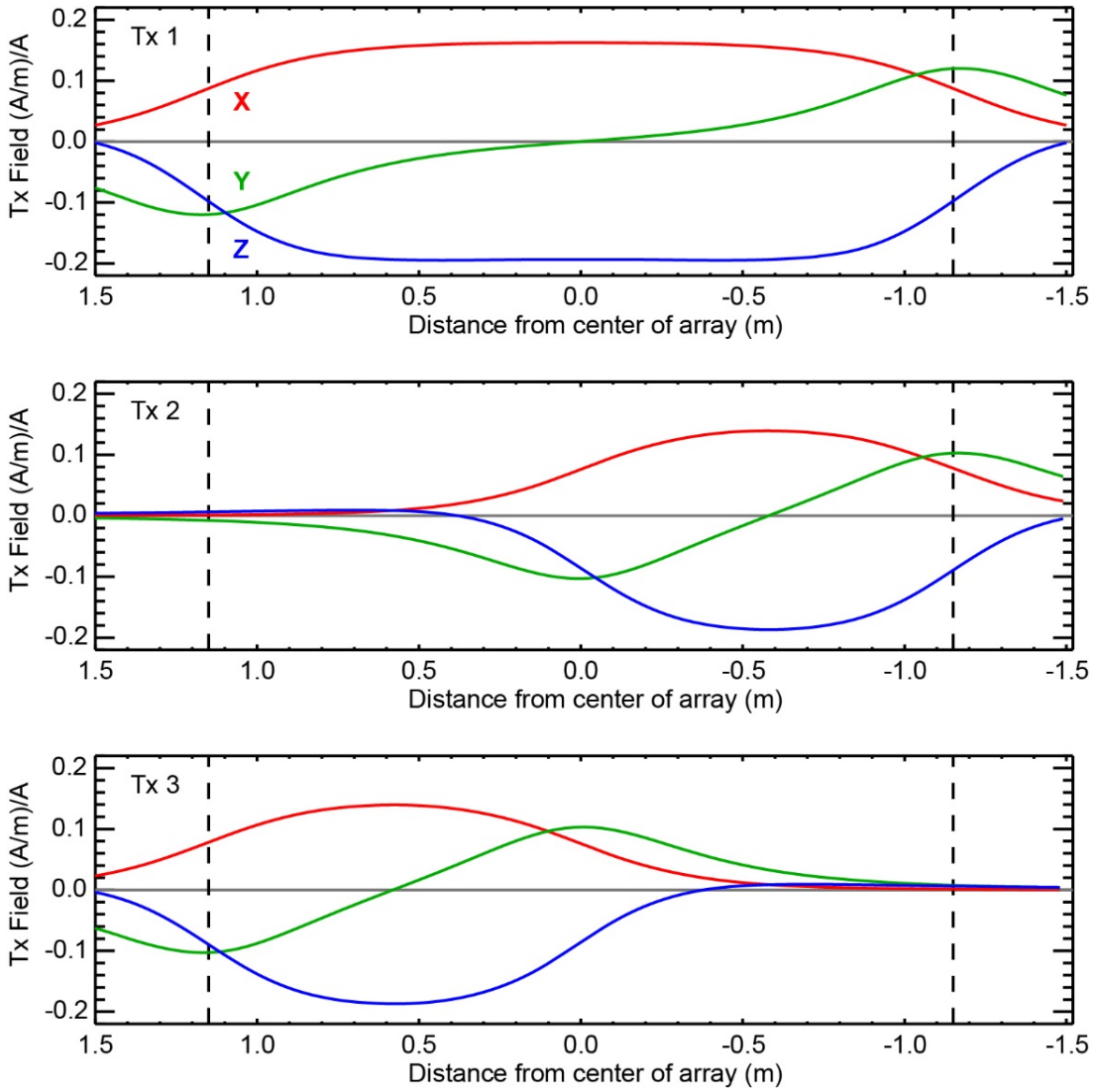
Primary Field Excitation

- Target must be excited by primary fields in three orthogonal directions
  - Y-axis excitation is weakest at the center of array for the outer loop
  - Paired inner loops give better Y-axis excitation over entire width of array



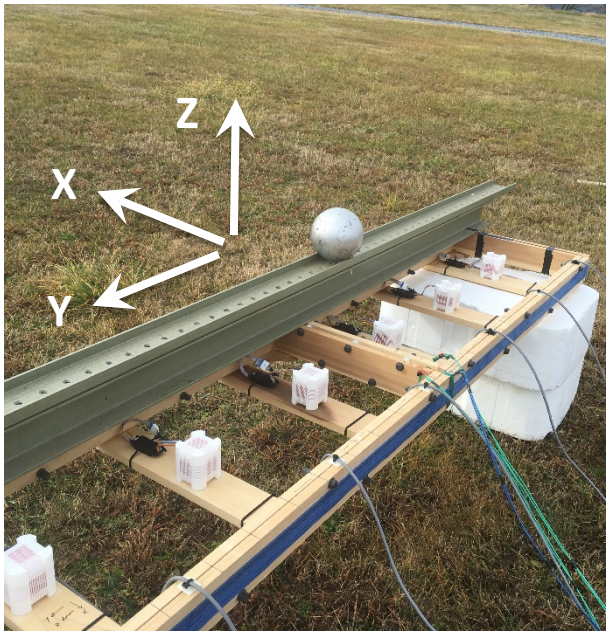
Primary Field Excitation

Primary field components 50 cm below array at its leading edge (x=25 cm)



“Dynamic Data” Roll Test

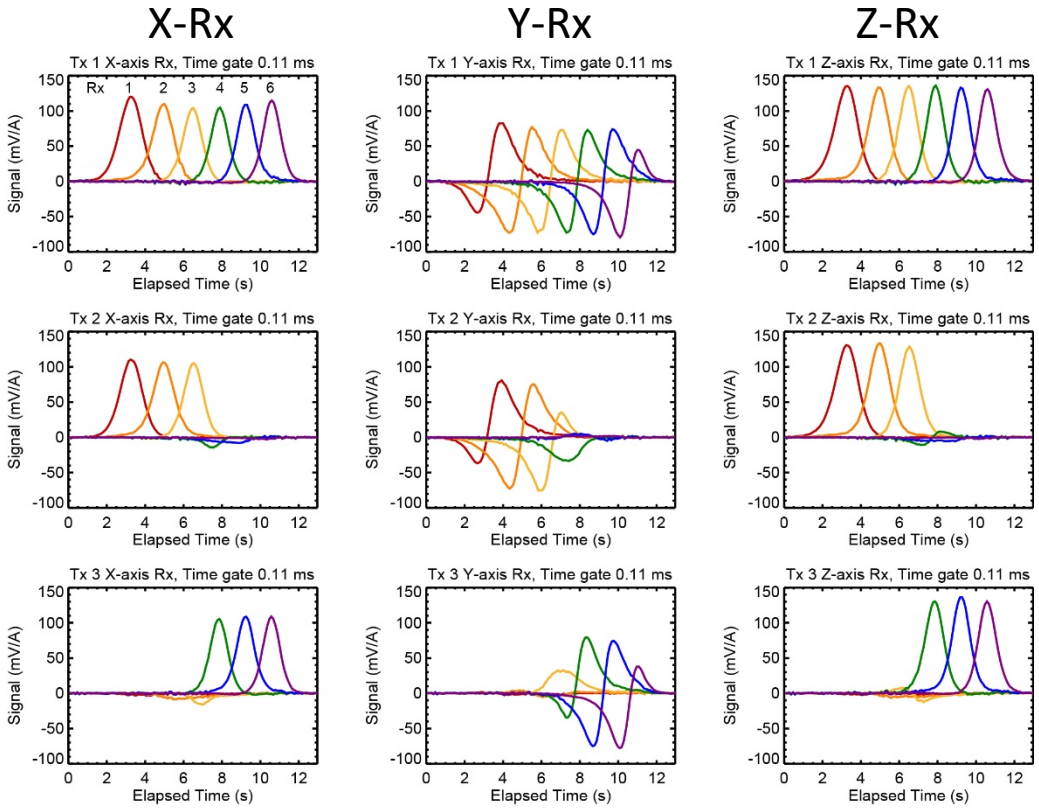
- Strong X,Y,Z response as ball passes each cube



Tx1

Tx2

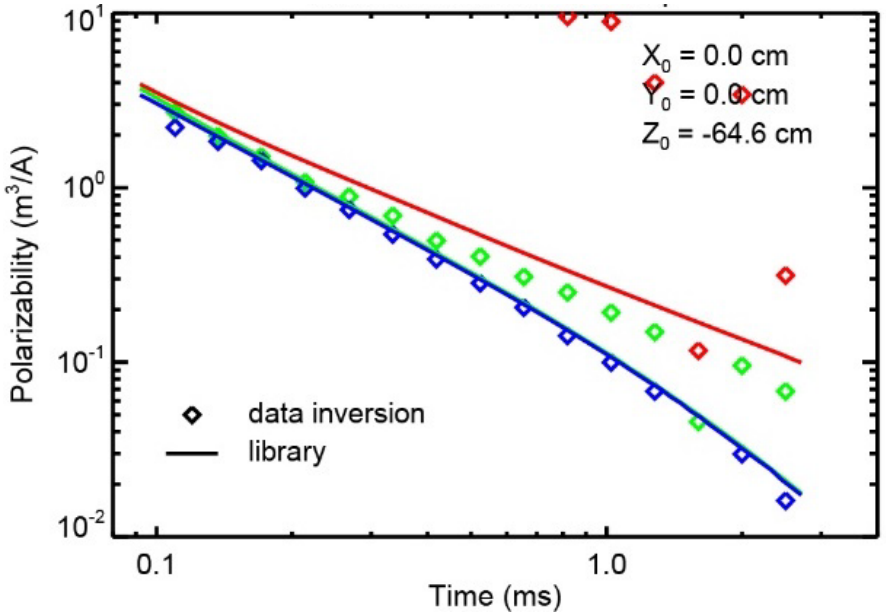
Tx3



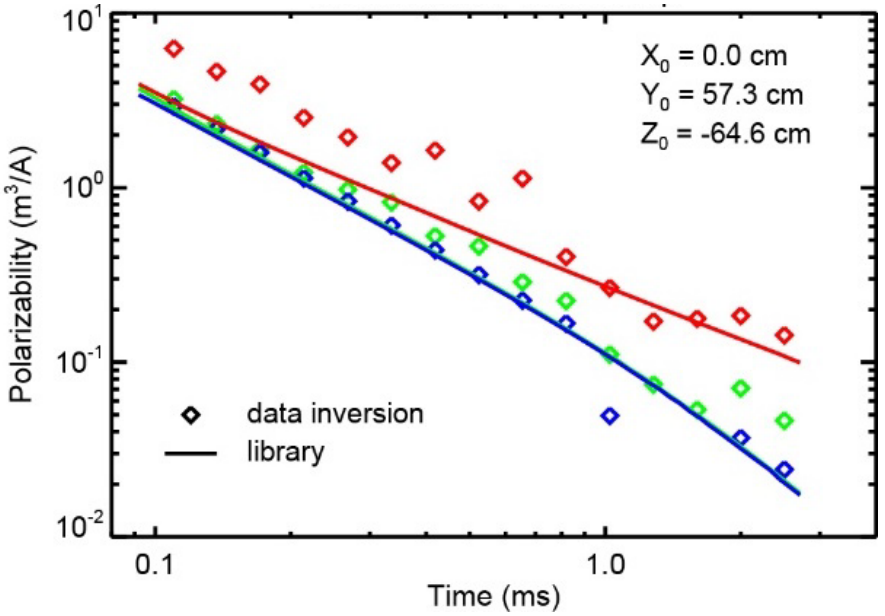
Classification: Outer Loop

- Polarizabilities not properly constrained
  - 57 mm projectile

Target under center of array



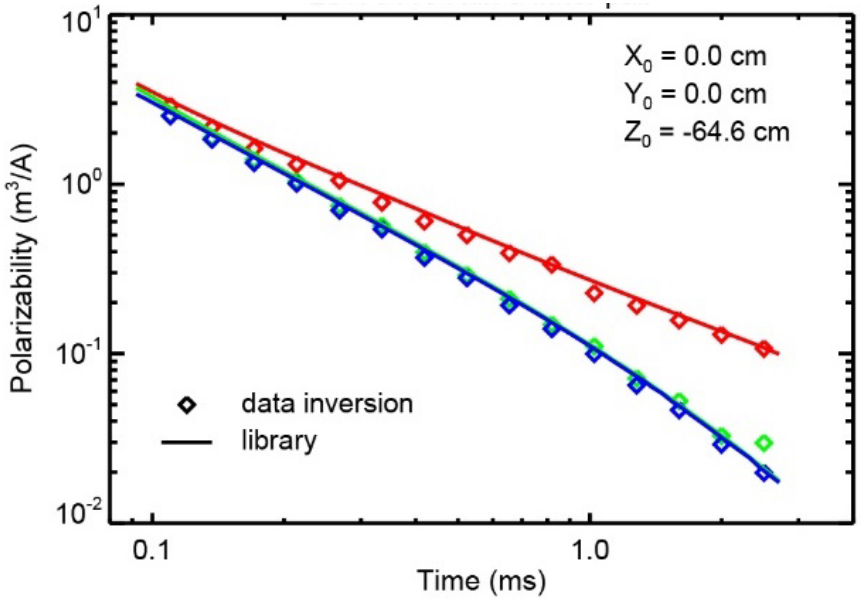
Target under center of inner loop (Tx2)



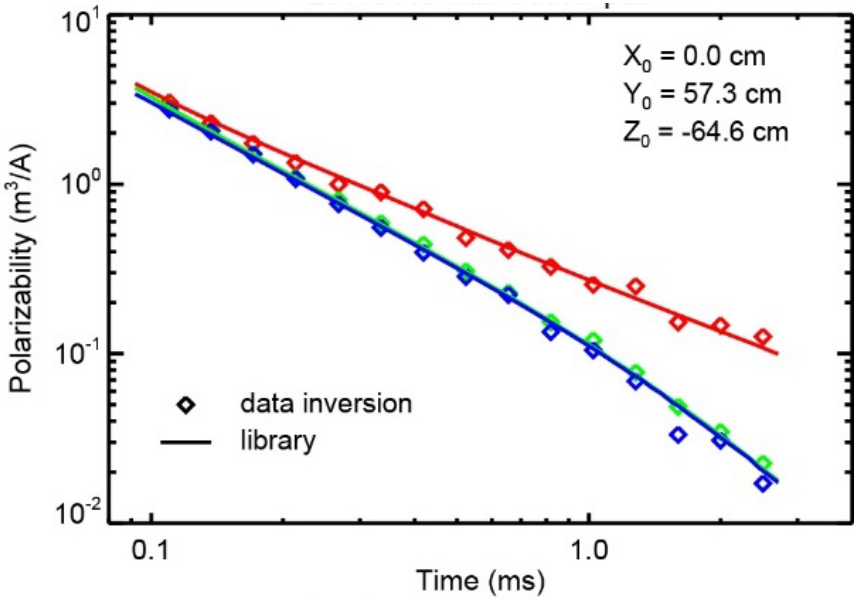
Classification: Inner Tx Pair

- Polarizabilities properly constrained
  - 57 mm projectile

Target under center of array



Target under center of inner loop (Tx2)

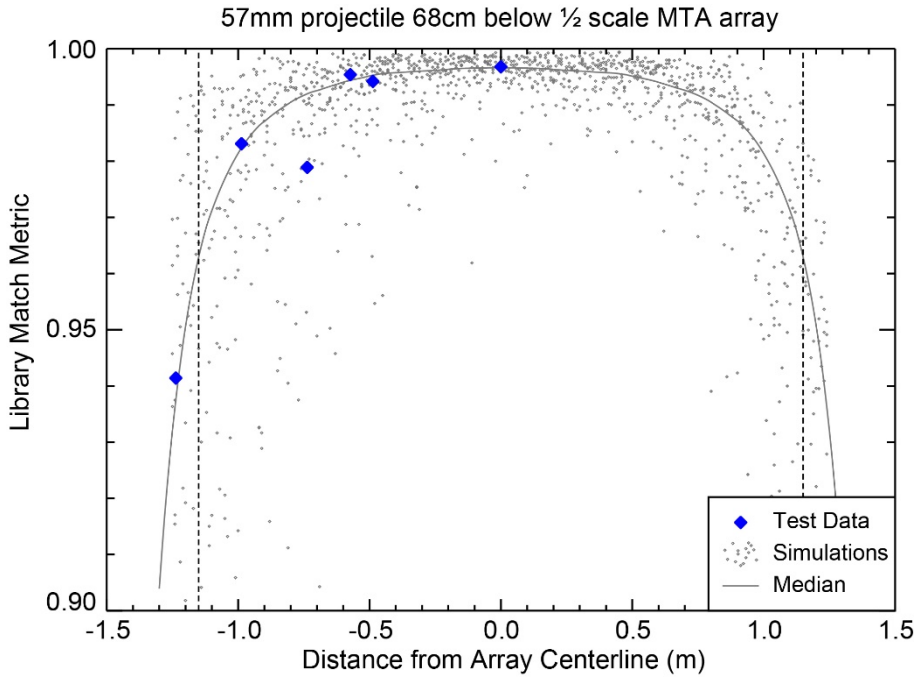


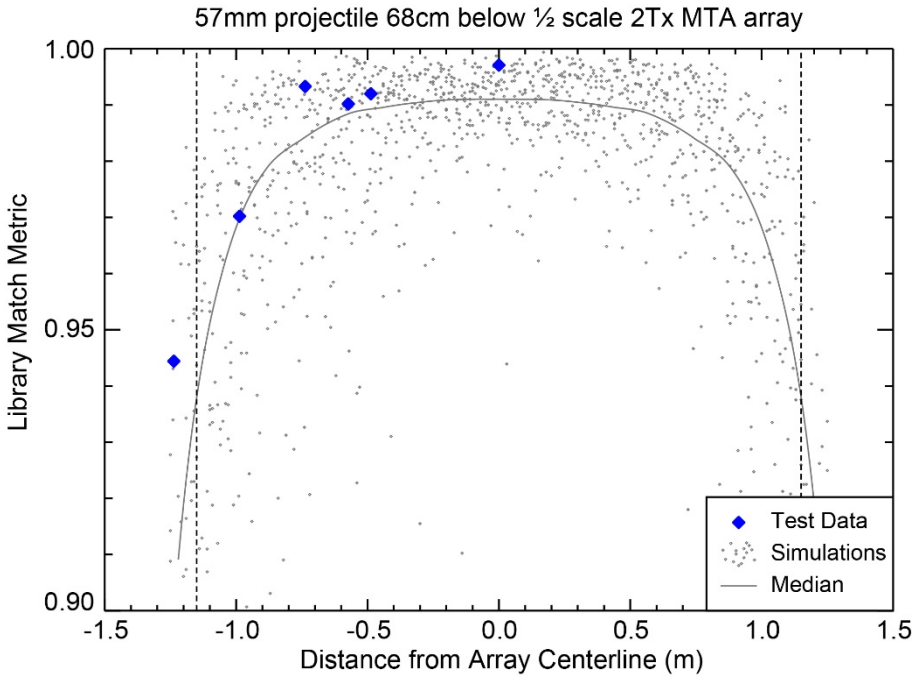
Classification Summary

	Avg. Position Offset (cm)	Avg. Library Match (0 → 1 = perfect)
Outer Loop Only		
Shallow, offset	2.4	0.7822
Deep, offset	4.3	0.8518
Inner Loops Only		
Shallow, offset	2.2	0.9997
Deep, offset	3.1	0.9780

Modeling Results

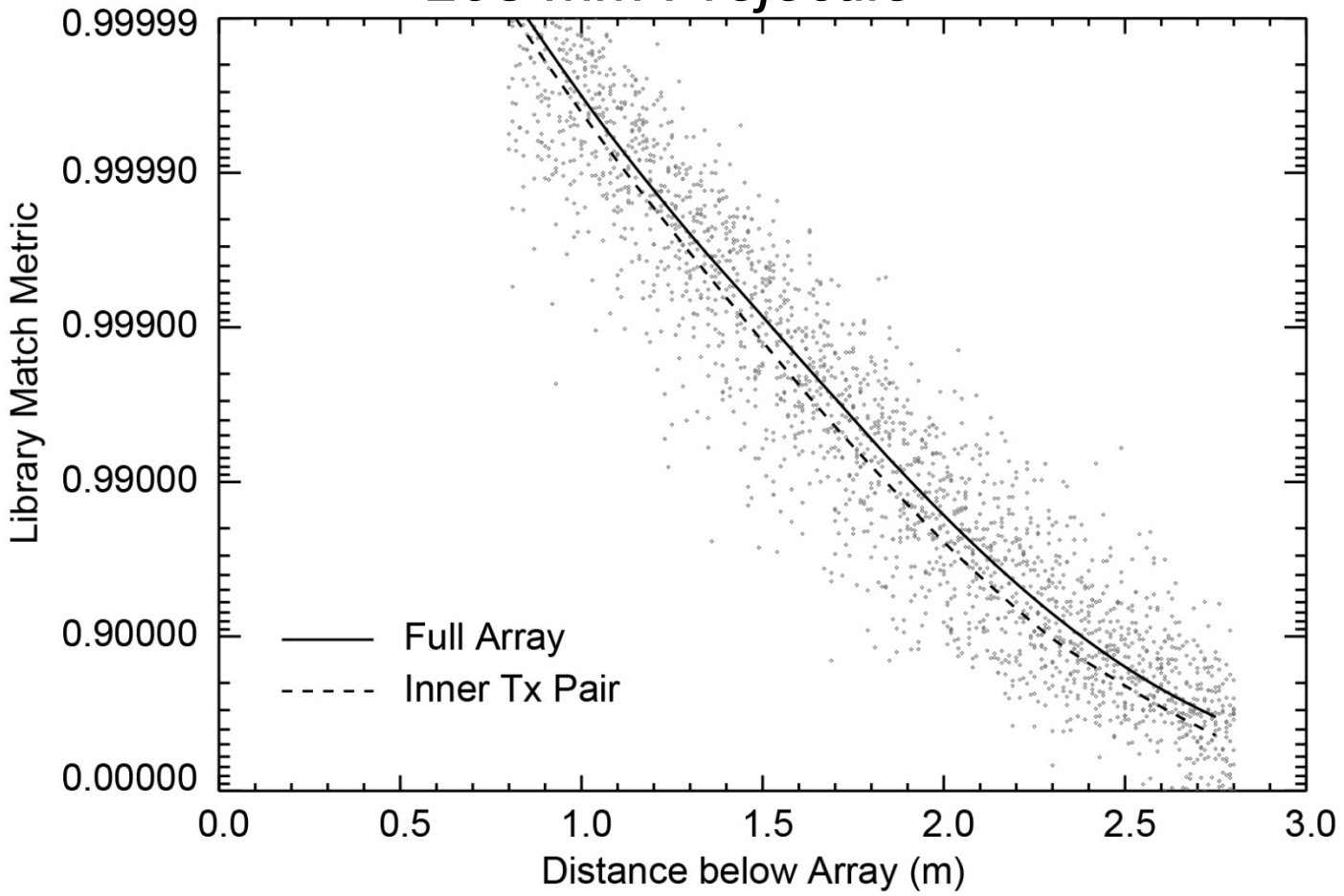
- Model developed from results to give predictive capability
  - How does the array behave?





Model Performance of Full Array

Simulation results for the full array, 480 A-turns, 105 mm Projectile



Conclusions

- New Marine Towed Array EMI array design successfully validated
  - The full array performs well over its entire width, as does the pair of inner coils by themselves
  - Classification performance models have been validated
- Half-scale model can robustly classify 57 mm projectiles at a range of 68 cm
  - Validated models predict that the array should be able to reliably classify large munitions (≥105 mm projectiles) at operationally useful depths
- Once functional, the Marine Towed Array will be a valuable tool in the DoD arsenal for detection and classification of underwater UXO

For additional information, please visit
https://www.serdp-estcp.org/Program-Areas/Munitions-Response/Underwater-Environments/MR-201610

Speaker Contact Information

daniel.steinhurst.ctr@nrl.navy.mil; 202-767-3556

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Q&A Session 1

Near-Shore UXO Arrays Deployed from Unmanned Platforms

Dr. Greg Schultz
White River Technologies

SERDP DOD ▪ EPA ▪ DOE | ESTCP

Agenda

1. Problem(s) statement
2. Underwater unmanned platforms
3. ROV and bottom crawler sensor integration
4. Challenges and considerations
5. Tests, lessons and application
6. Synopsis, future prospectus/transition

Overarching Problem

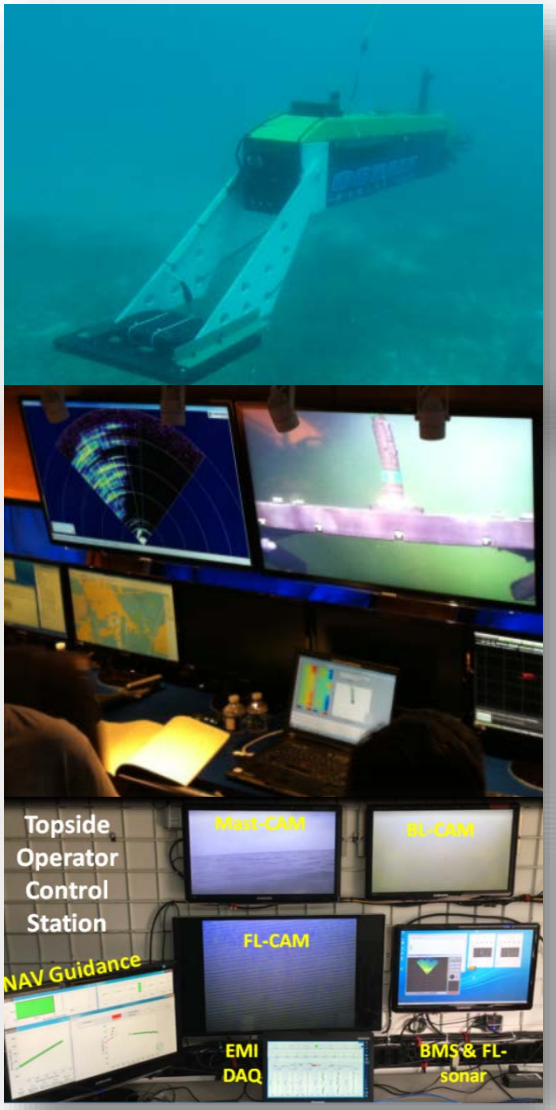
- Pervasive marine UXO and associated high cost of underwater operations driving need for technology
- Current UXO survey technologies limited to diver-based sensors or towed sensor fish or arrays
  - Need for new technologies tailored for addressing seabed UXO mapping and characterization

Traditional Manned Approaches

- Divers → limited depth and duration
- Cost associated with dive personnel and topside logistics
- Tow fish sensor → limited depth
- Single-axis methods only (lack characterization capability)
- Limited motion control
- No real-time situational awareness, data sharing, processing, or identification

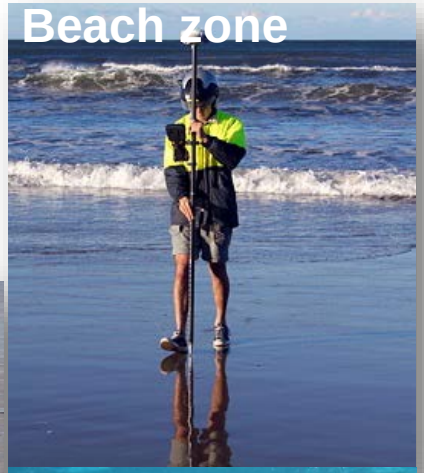
Current Needs

- Nearshore and littoral UXO surveying
  - Operate very close to the seafloor (<1 m)
  - Operate in multiple environments and in water depths >30 meters
  - Provide real-time situational awareness and dynamic repositioning
  - Detect and discriminate small munitions under varied conditions
  - Acquire multiple data types (sonar, video, geophysics) simultaneously



Nearshore Challenges

- Waves, mud, clutter, biologics, exposure pathways, etc.



e.g., Camp Lejeune, Raritan Arsenal, Duck, Surf City, Vandenburg, Mare Island, Wood Island, Vieques, Marthas Vineyard

R&D Questions: Filling the gap

- How can we operate non-acoustic UXO sensors in coastal and littoral environments?
- What existing/emerging platforms and technologies can we bring to bear?
- How close to the seafloor can we survey?
- What positioning accuracy is possible?
- What methods and metrics are appropriate for assessing new nearshore UXO technologies?

Leveraging Unmanned Systems

- Capabilities
  - Depth and duration
  - Motion control
  - Safety and efficiency
  - Level of autonomy
- Considerations
  - Size, weight, power
  - Platform noise
  - Launch and recovery
  - Sensor integration

ROV-Sensor Integration

- Types and considerations
  - Small inspection ROVs
  - Workhorse ROVs
  - Custom hybrid AUV/ROVs
    - Tethered or not → topside support
    - Launch/recovery infrastructure
    - Stability, thrust and maneuverability
    - Payload support
    - Cost (lease or own?)

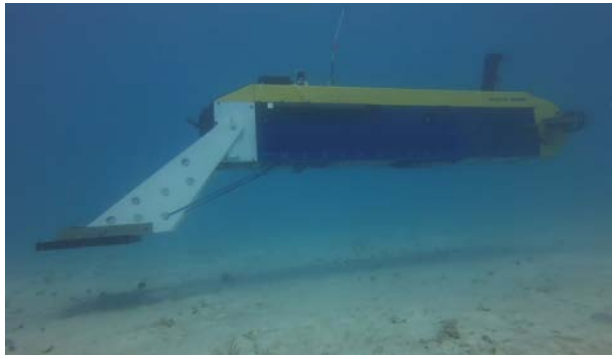
Seabotix vLBV

Saab Subsea ROV Line

HAUV-1000

ROV-EM Maneuverability

HAUV-1000

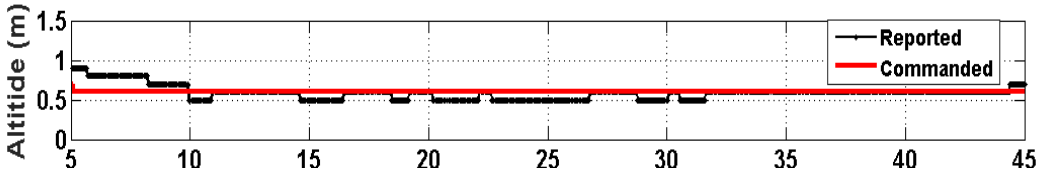


Bottom Following (18 Runs)

ΔAlt = 10 cm
σAlt = 3 cm

ΔRoll = 0.14 deg
σRoll = 0.11 deg

ΔPitch = 0.29 deg
σPitch = 0.20 deg

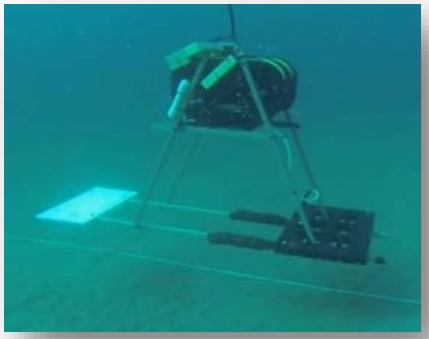


Station Keeping (5 mins)

ΔE, ΔN = 12 cm, 13 cm
σE, σN = 5.7 cm, 6.7 cm

ΔYaw = 0.86 deg
ΔRoll = 0.31 deg
ΔPitch = 0.27 deg

vLBV-300

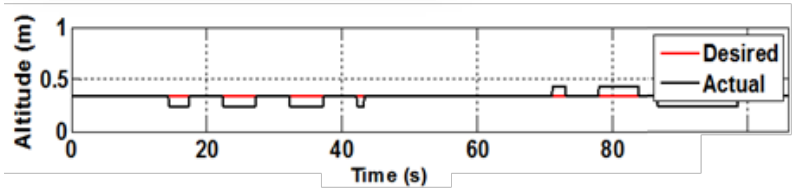


Bottom Following (All Runs)

ΔAlt = 4 cm
σAlt = 7 cm

ΔRoll = 0.88 deg
σRoll = 2.1 deg

ΔPitch = 1.58 deg
σPitch = 2.1 deg

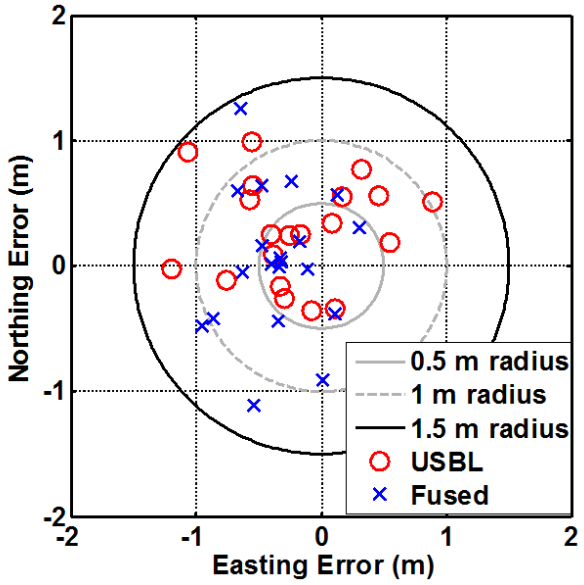


Station Keeping (3 mins)

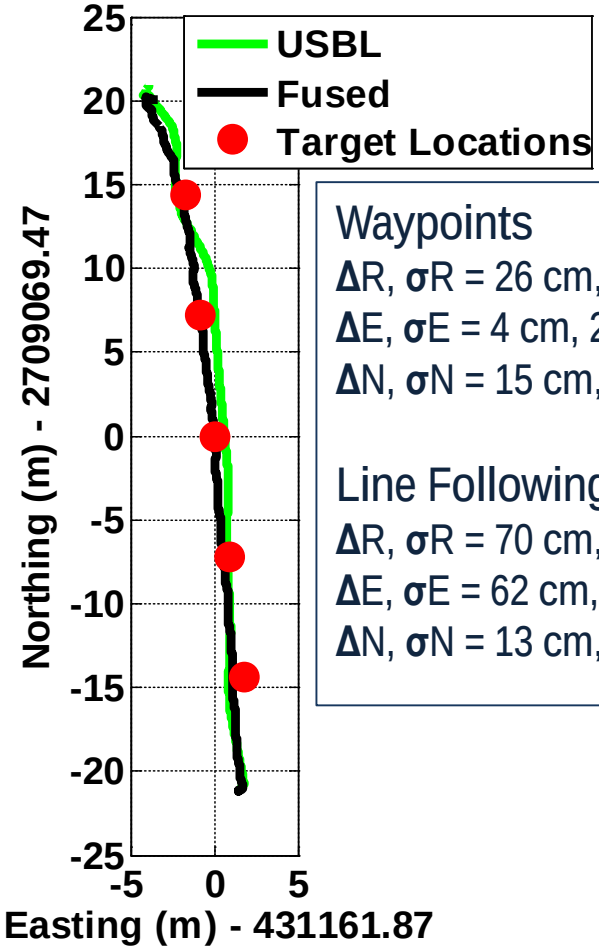
ΔE, ΔN = 25 cm, 10 cm
σE, σN = 15 cm, 21 cm

ΔYaw = 0.02 deg
ΔRoll = 0.03 deg
ΔPitch = 0.90 deg

ROV-EM Maneuverability



Waypoint / Line Following



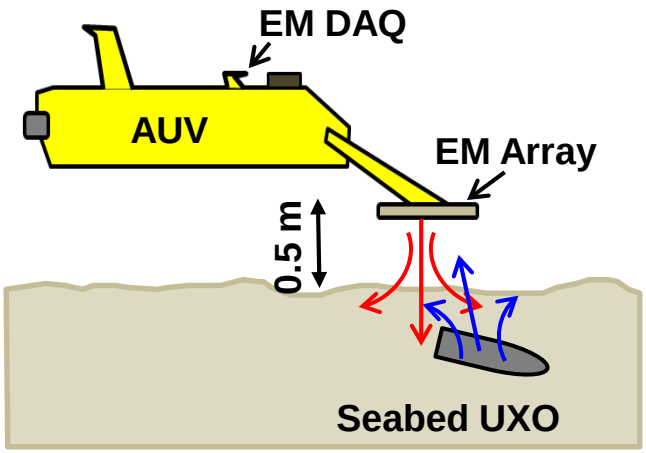
Waypoints

ΔR, σR = 26 cm, 29 cm
ΔE, σE = 4 cm, 28 cm
ΔN, σN = 15 cm, 23 cm

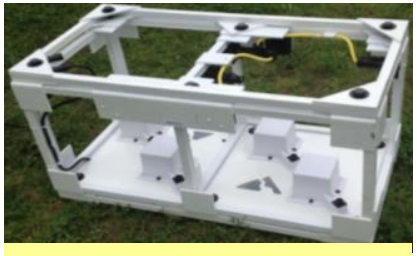
Line Following

ΔR, σR = 70 cm, 53 cm
ΔE, σE = 62 cm, 59 cm
ΔN, σN = 13 cm, 16 cm

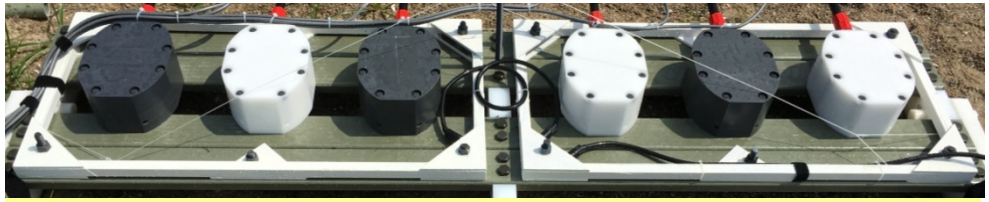
ROV-EM Maneuverability



MFDA (FDEM 1x6)

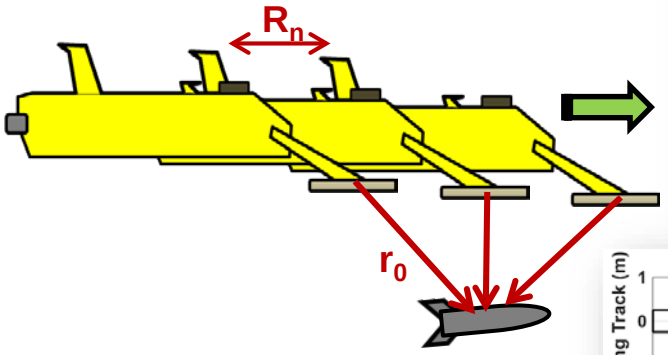


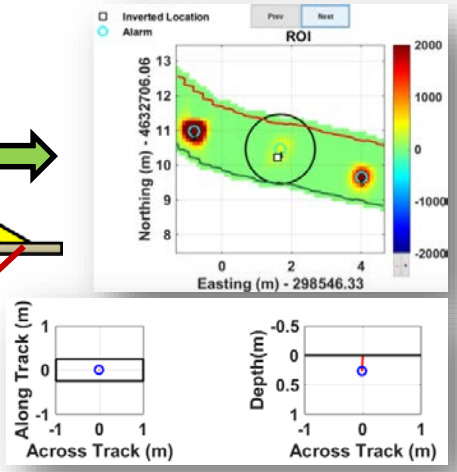
EMPACT 3D (TDEM)

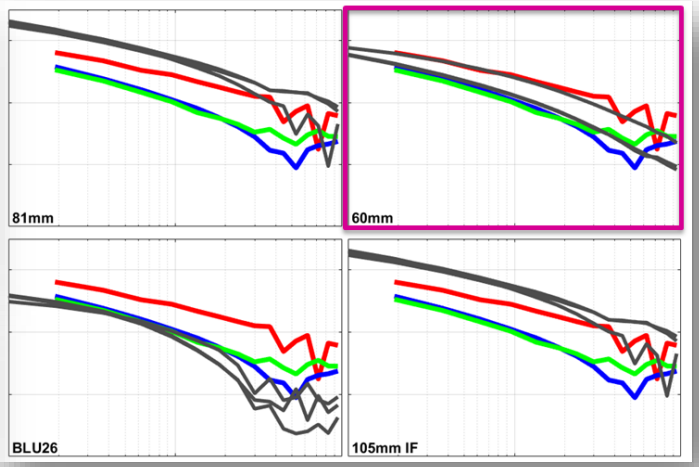


Flex-EM 3D Array (TDEM 2x6)

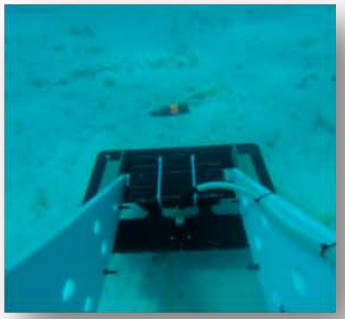
Multi-static/multi-angle illumination

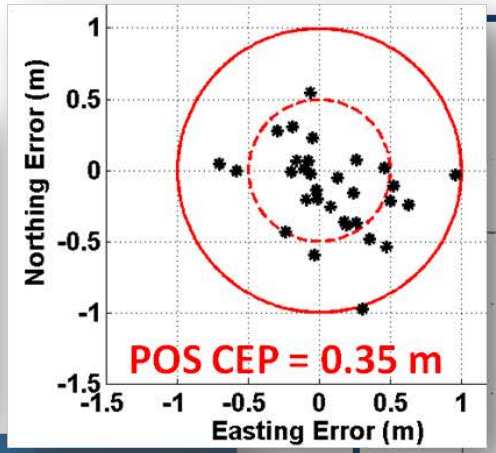


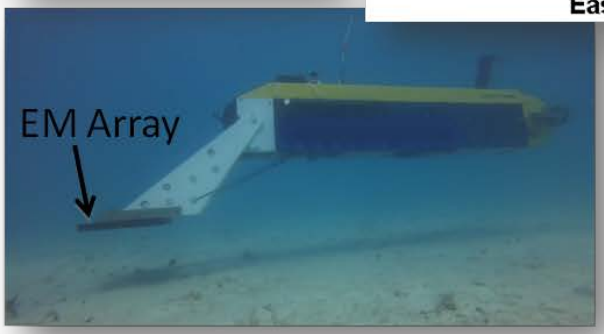


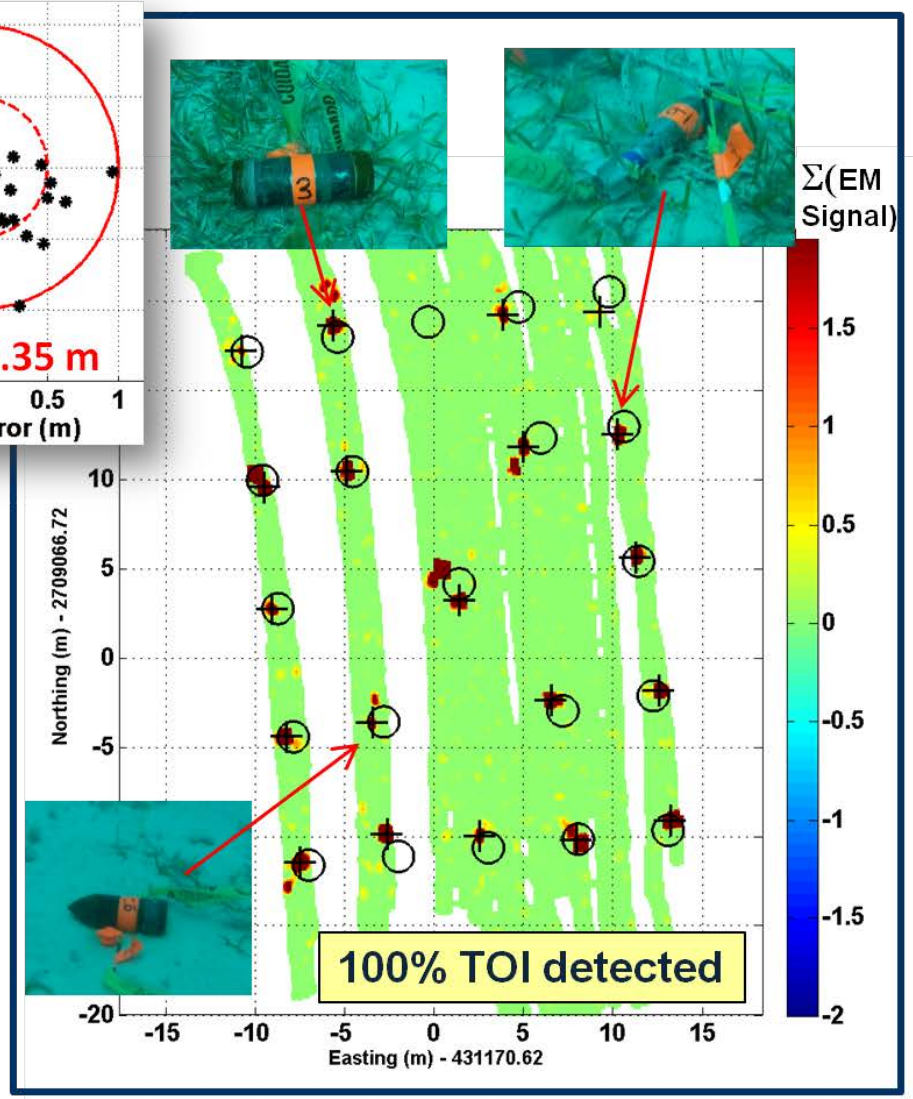


ROV-EM: Effectiveness and Transition





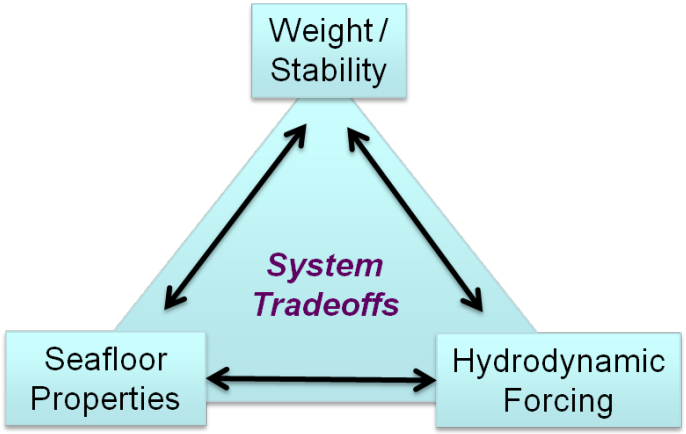




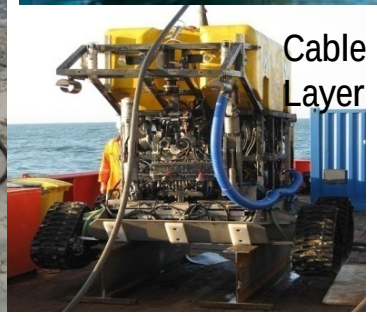
Amphibious Platforms

System Feature Tradeoffs

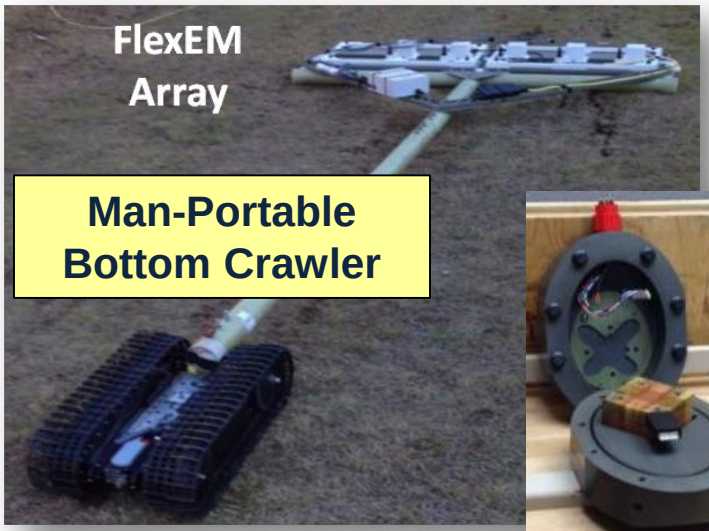
- Stability
- Pull force, payload capacity
- Size, weight, power, cost
- Depth, endurance, range
- Traction / trafficability
- Launch and recovery

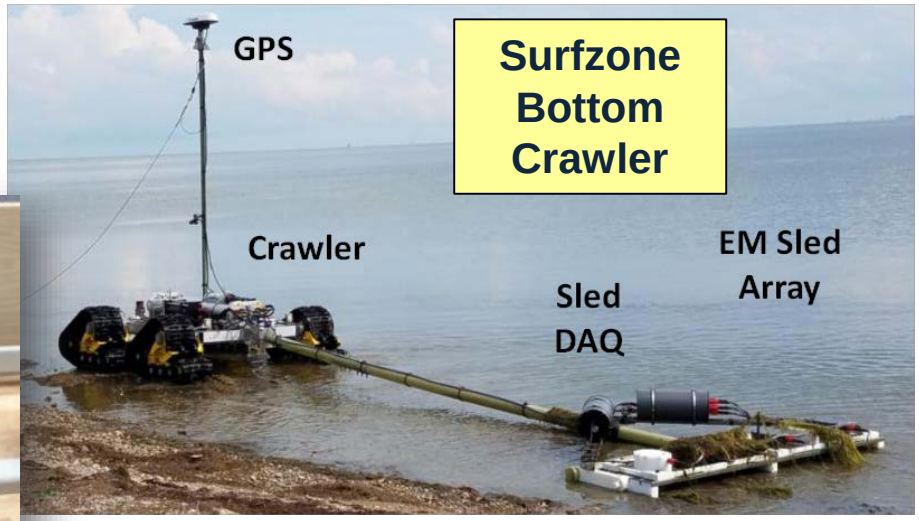


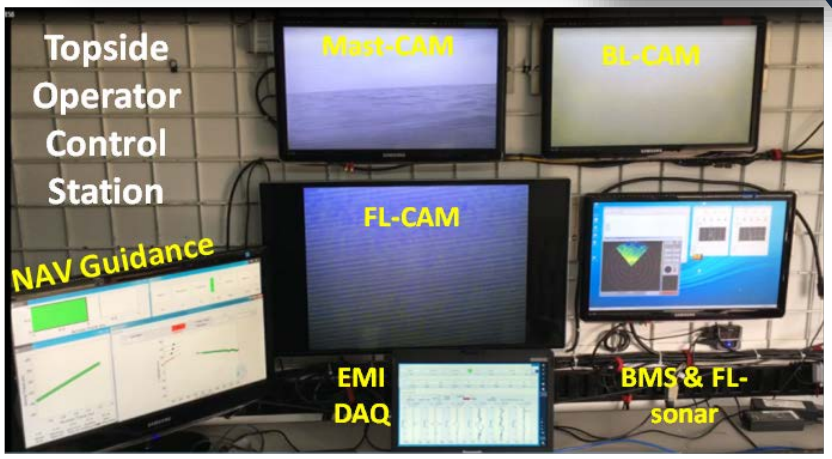
increasing bottom contact



Bottom Crawler-Based Sensing

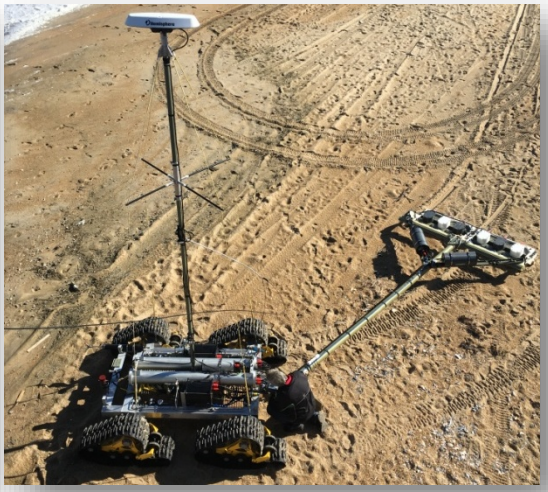


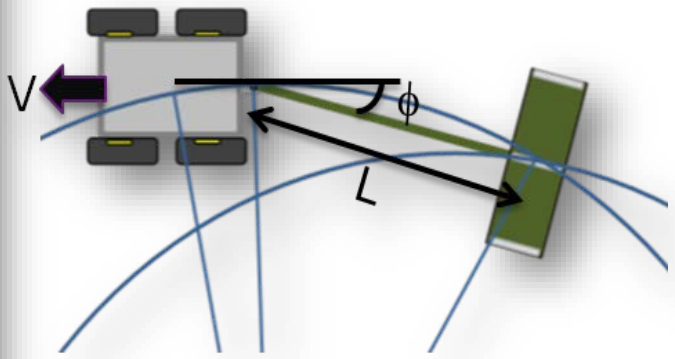


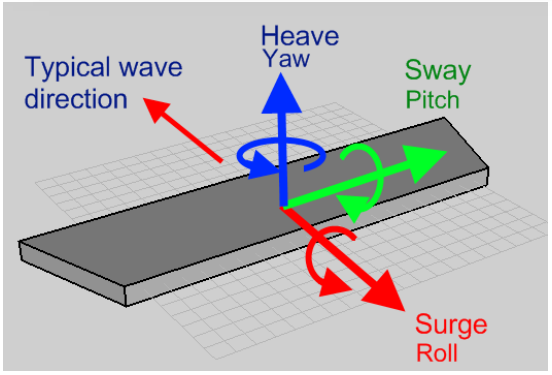


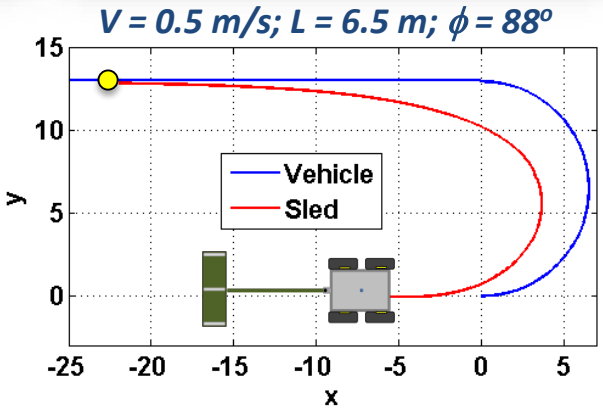
Towing Arrays

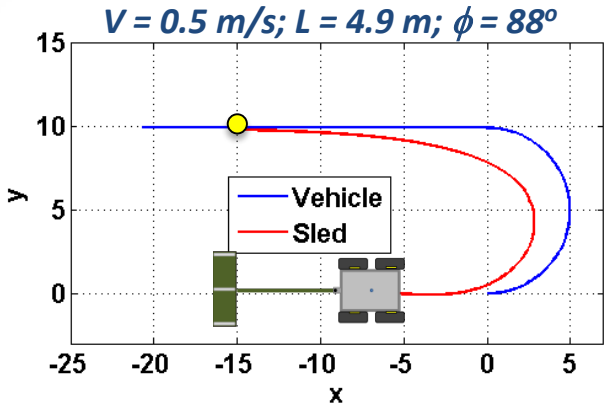
Considerations for noise and positioning



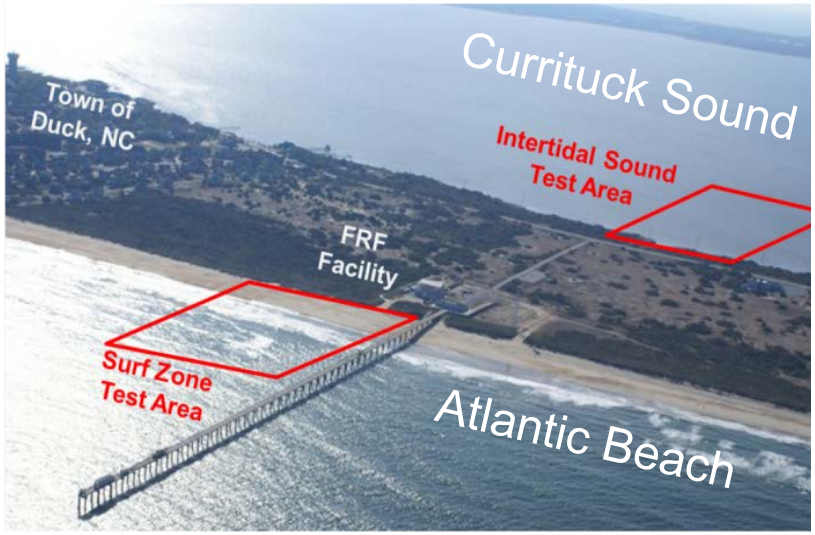


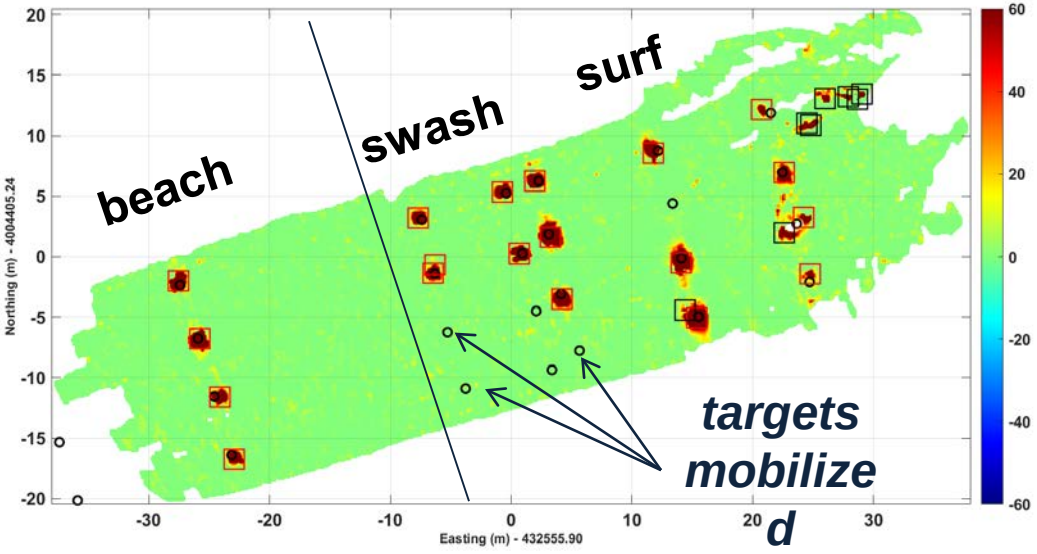


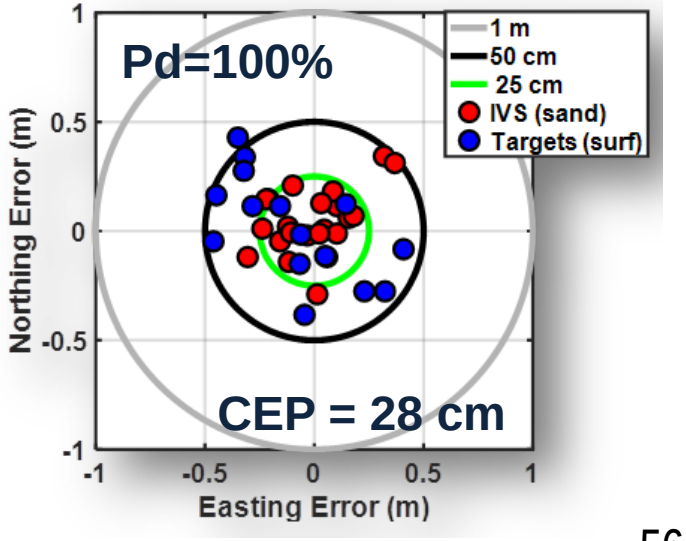




Surf Zone Testing

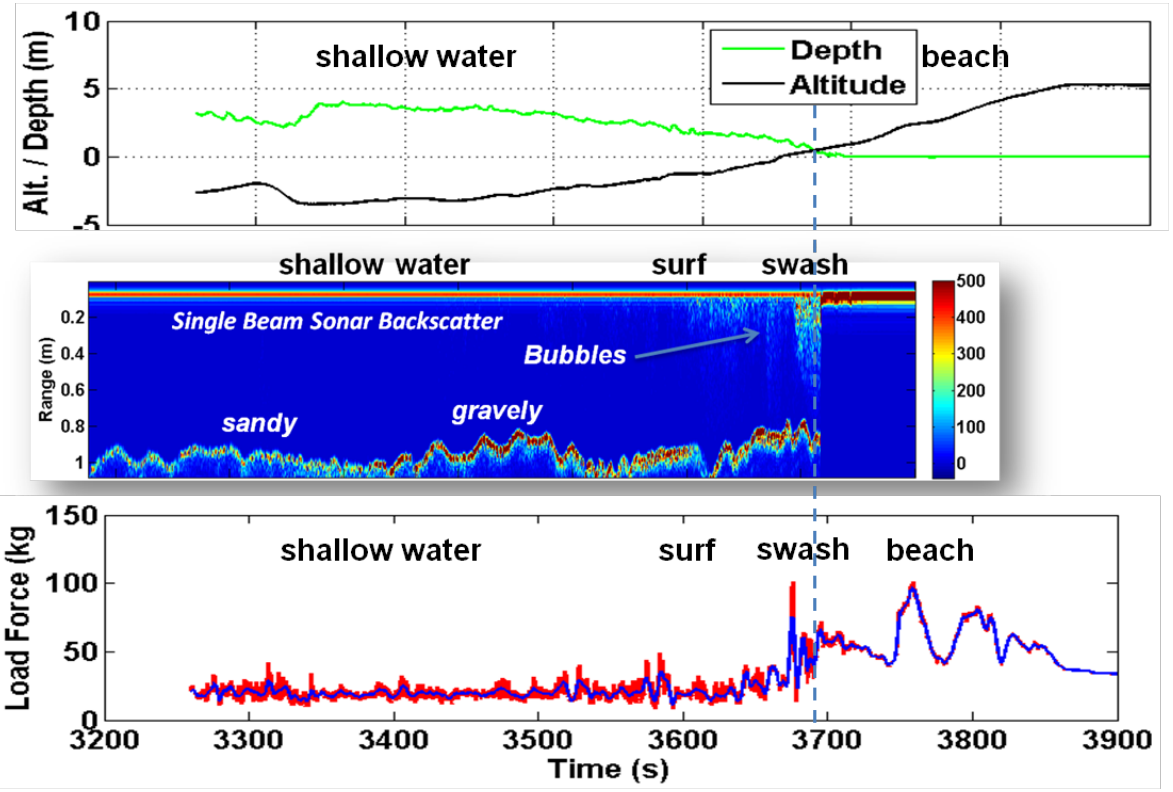


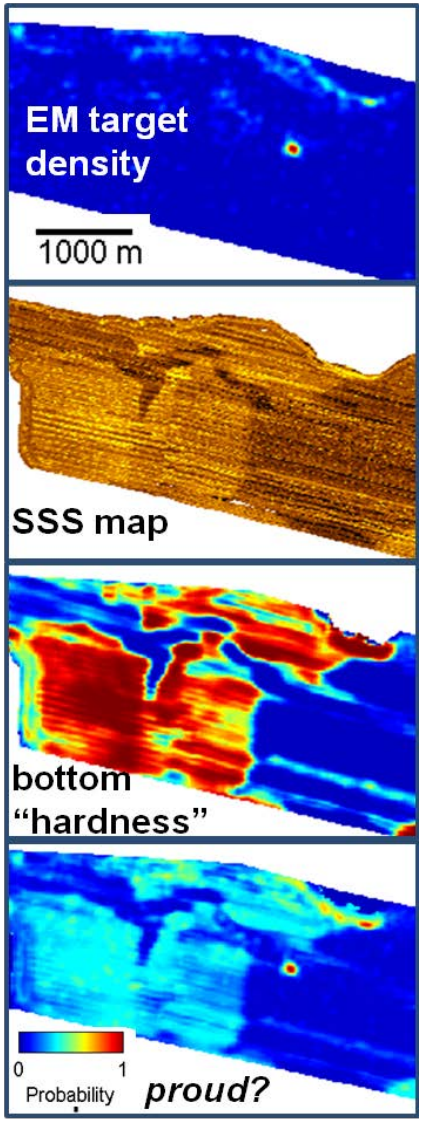




Bottom Contact → Trafficability

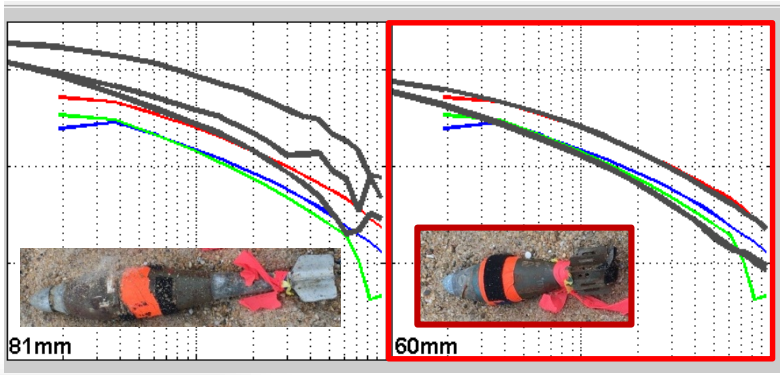
- Interaction with bottom
  - Stability, mobility, traction, scour

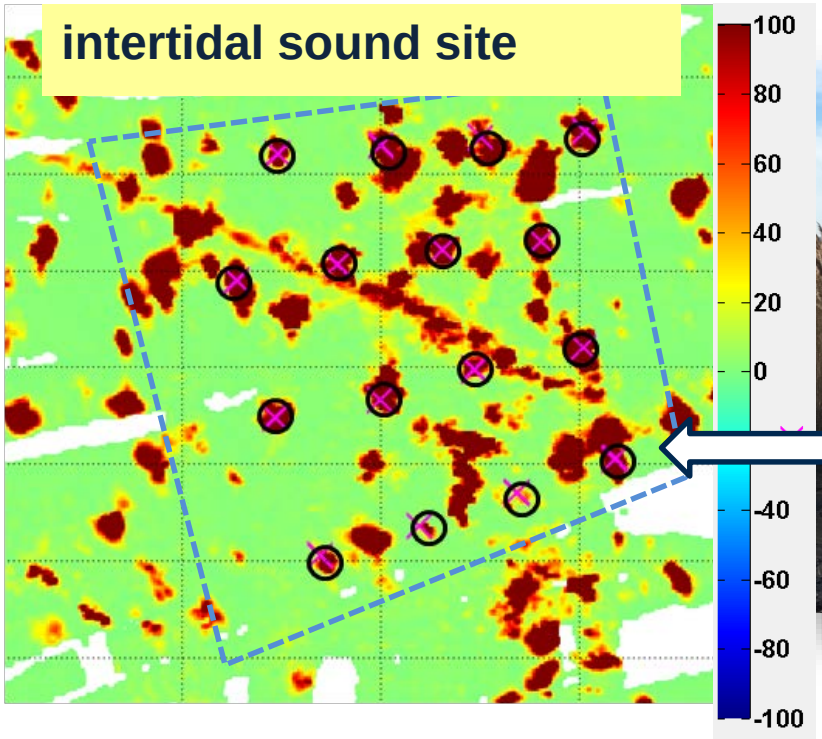


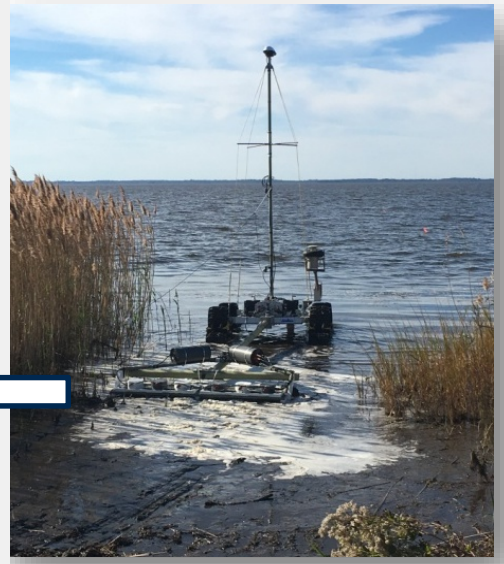


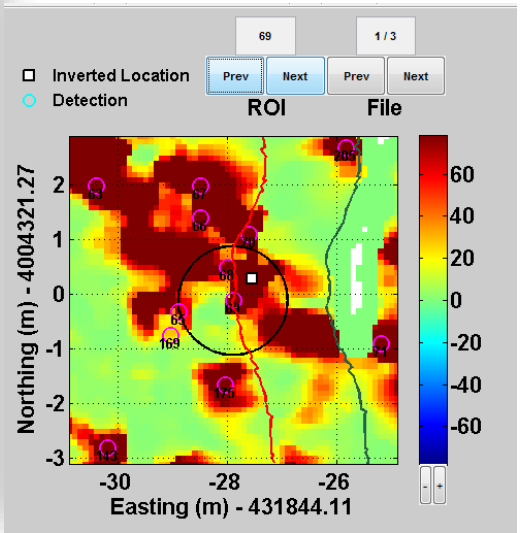
Sound/Marsh Testing

- 20 cm of mud, grass
- Highly cluttered
- Good overlap → P_{class}







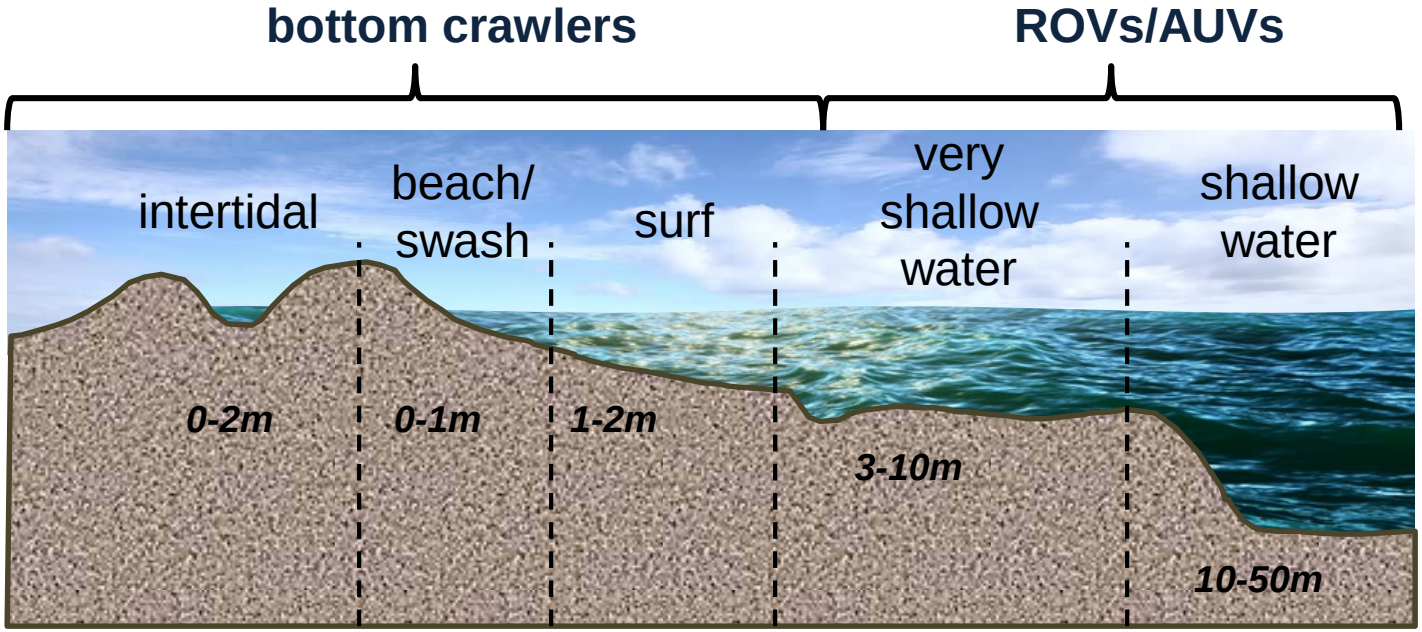


...yikes!

Transition

Operating Envelopes (Environments/Missions?)

- Crawler-Towed EM
  - GPS and Radio Link
  - Trafficability / Contact
  - Maneuverability
- ROV-based EM
  - USBL / non-GPS
  - Local Area Surveys
  - Hydrodynamics



Synopsis and Conclusions

- Unmanned platform EM array system deployment fills gaps where diver and towfish UXO systems untenable
  - Close-in and controlled sensing → detection of small UXO to within 1 m (bottom and waypoint following)
  - ROV-based EM effective in shallow water (LAR and swim-ability function of ROV size)
  - Crawler-towed EM effective for amphibious UXO operations over variety of nearshore areas (e.g., surfzone and muddy intertidal areas)
  - Both ROVs and crawlers → safe standoff and continuous/consistent operation without divers or boats (potentially at significant cost savings)

Future Work

- New system deployments
  1. Underwater Dynamic Classification System: MR-201614
  2. Man-Portable Crawler-EM System: MR-201712 (with C2I)
  3. Expeditionary ROV Array System (STTR N17A-T015 with Woods Hole Oceanographic Institution)
  4. UUV-based Streamer Systems (STTR N17A-T028 with Woods Hole Oceanographic Institution)

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- Dr. Tim Crandle (SeaView Systems)
- Arnis Mangolds (C2I)

For additional information, please visit
www.serdp-estcp.org/Program-Areas/Munitions-Underwater/MR-201233
www.serdp-estcp.org/Program-Areas/Munitions-Underwater/MR-201422

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Q&A Session 2

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