Highly Integrated Autonomous ROV-based 3DEM for Underwater AGC

MR22-7454

Greg Schultz

White River Technologies

In Progress Review Meeting

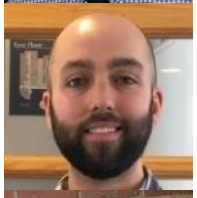
21 MAY 2025

Project Team

WHITE RIVER TECHNOLOGIES

University of New Hampshire
College of Engineering and Physical Sciences

Dr. Gregory Schultz (PI), WRT
EM Sensing & UXO Tech Development



Dr. Joshua Elliott, WRT
Undersea Mechatronics, Robotics, & Automation & Controls

Cristel Callupe, WRT
Lead EM System Engineer

Dr. May-Win Thein, UNH
Professor, Marine Robotics

Dr. Ozzy Oruc, Citadel←UNH
Undersea Robotics & Naval Design

DB Bhowmick, WRT←UNH
Robotics Test Engineer

ESTCP

Bottom Line Up Front

Technology Focus

- *Cost-effective methods for integrated Remotely Operative Vehicles & underwater 3DEM technology for shallow water UXO site assessment*
- *ROV-based AGC with optional deployment from an ASV*

Accomplishments

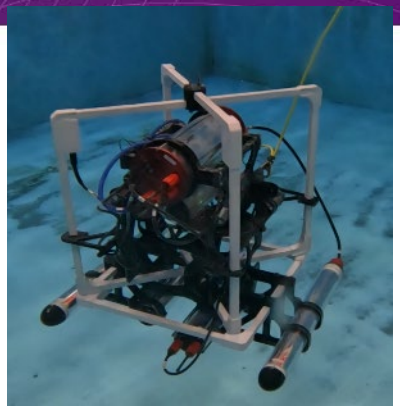
- *Transitioned mAPEX from BlueROV-2 to MSS Defender ROV unit*
- *Validated dynamic surveying and static AGC via land & in-water tests*
- *Implemented coherent noise filtering approach to reduce ROV motor noise*
- *Completed demonstration plan for limited in-water data collection*

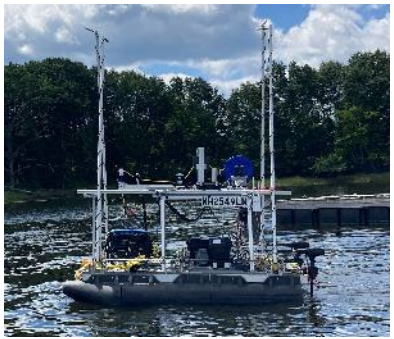
Challenges

- *Significantly reduced scope of project → abbreviated demonstration planned*
- *Geo-positioning and navigation of ROV-EM currently less accurate than desired*

Implementation Support

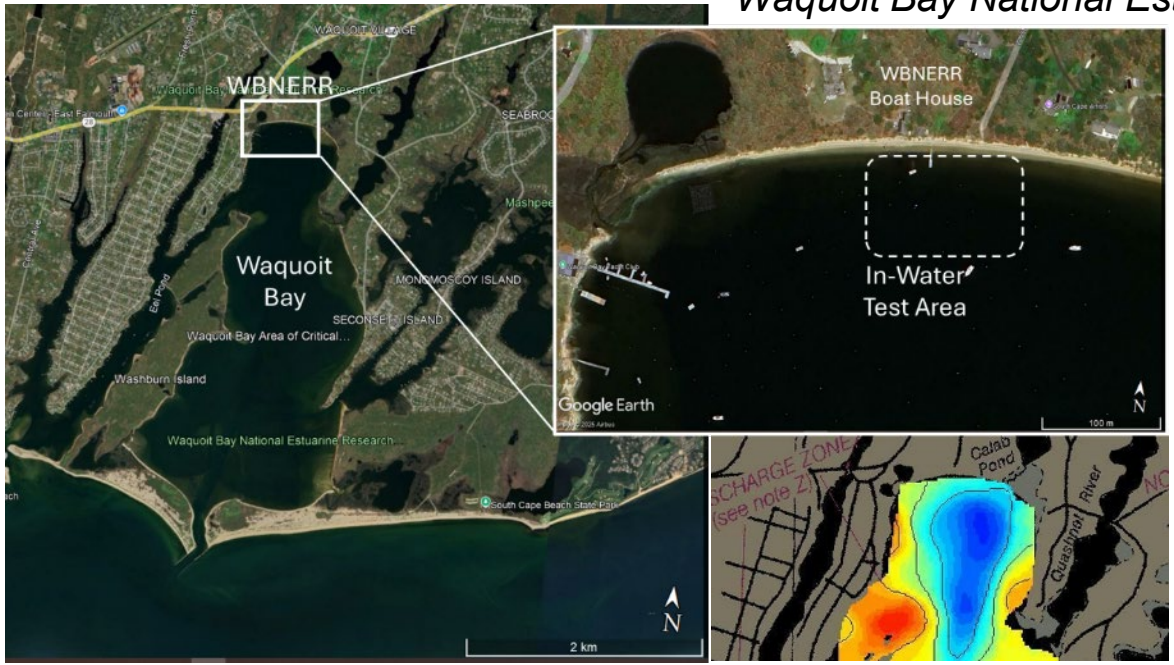
- *In-water demonstration will be conducted at Waquoit Bay, MA (WBNERR)*

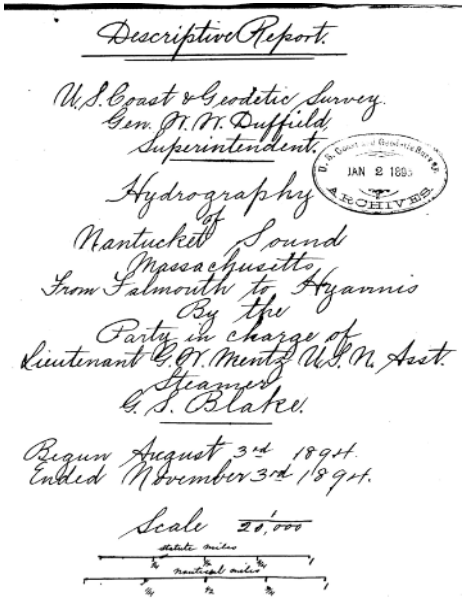




Site Description

Waquoit Bay National Estuarine Research Reserve (WBNERR)




Descriptive Report.

U.S. Coast & Geodetic Survey.
Gen. F. M. Duffield
Superintendent.

JAN 2 1895
ARCHIVES

Hydrography
of
Nantucket Sound
Massachusetts
From Falmouth to Hyannis
By the
Party in charge of
Lieutenant C. H. Mentz U.S.N. Asst.
Steamer
C. S. Blake.

Begun August 3rd 1894.
Ended November 3rd 1894.

Scale 20,000
statute miles
nautical miles

Sandy bottom; 2-3 ft tidal range; ~30PSU salinity (42 mS/cm); Maximum depth 2.5 meters (0.25 meter contours in bathy image)

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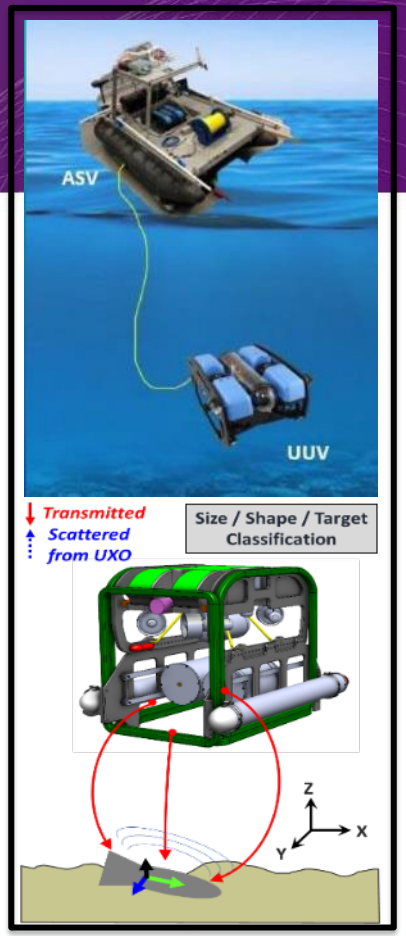
Technical Approach

1. **Integrate underwater 3DEM UXO classification with marine autonomy control systems**
2. **Validate tightly integrated form factor on small ROV with autonomous survey control**
3. **Assess integrated solution: ASV-based launch & positioning of ROV-EM system** (centralized communication, coordination, and positioning)
4. **Demonstrate full scale operations at a prepared test site**
5. **Develop transition products including use-case scenarios, best operating practices, and docs**



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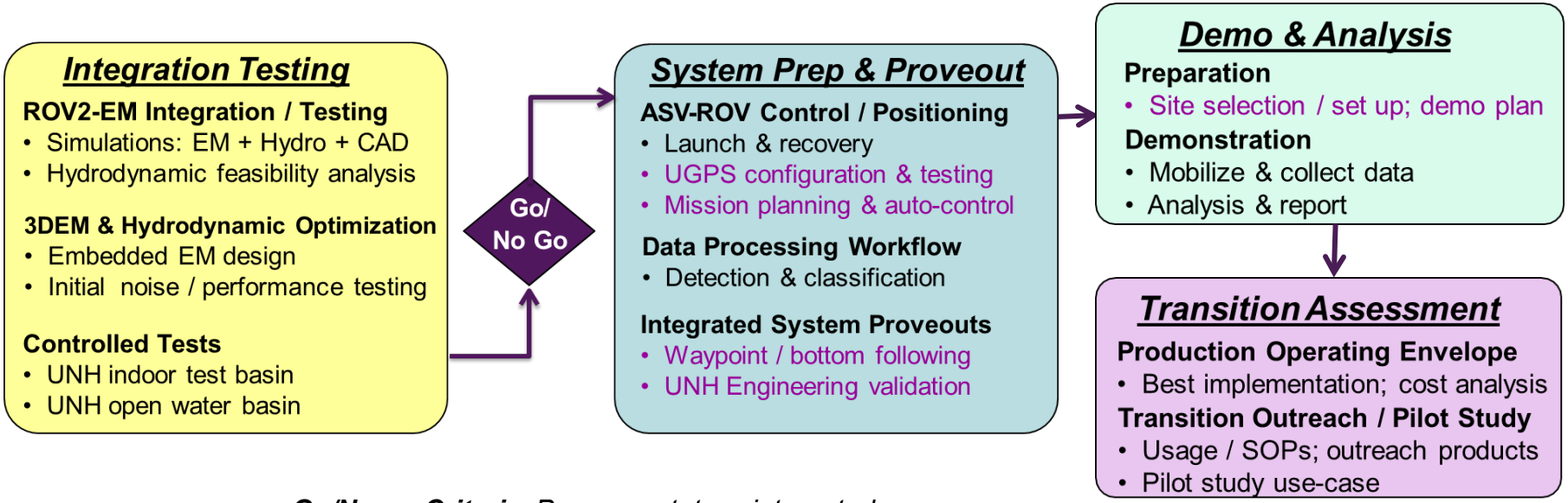
Technical Approach



***Go/No-go Criteria**: Proven prototype integrated system control & EM AGC performance*

Performance Objectives

Objective	Example Metric	Example Criteria
Waypoint Navigation	$\Delta R = (\Delta N^2 + \Delta E^2)^{1/2}$	ΔR <1m; 0.5% DT; σR < 50cm
Bottom Following	DA = ||cmd_Alt – obs_Alt||	ΔZ < 20 cm; σZ < 20 cm
Detection SNR (or P_D)	SNR = $\max(A_{signal})^2$ / $\max(A_{noise})^2$	SNR>9 dB or Pd>0.95 w/ Pfa~0.01
Clutter Rejection (AGC)	Pclass = # True Labels / #TOI	Clutter Rejection >65%
Detection Accuracy	ΔN & ΔE = ||est_XY – true_XY||	ΔN & ΔE < 100 cm
Coverage Rate	Acres / day	1 acre/day; full coverage
Ease of Use & Stability	Operator Observations	Compared to other Ops/ROVs

Technical Progress Summary

Task 1. ROV+3DEM Integration & Testing

- *Transitioned from BlueROV to MSS Defender ROV*
- *Hydrodynamic Optimization (Trim & Balance)*

Task 2. ASV-ROV Configuration & Mission Control

- *Demonstrated ROV deployment / recovery*

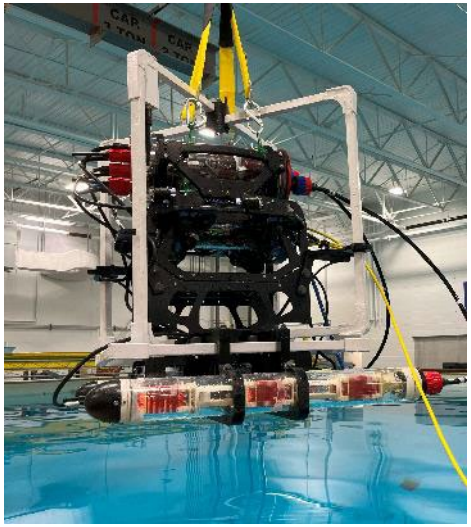
Task 3. Integrated System Prep & Proveouts

- *Waypoint mission planning & bottom tracking*
- *Demonstration Plan (abbreviated)*

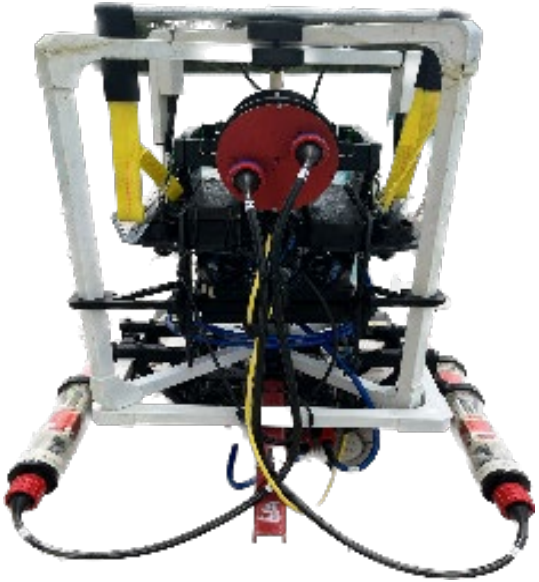
Task 4. Field Demonstration

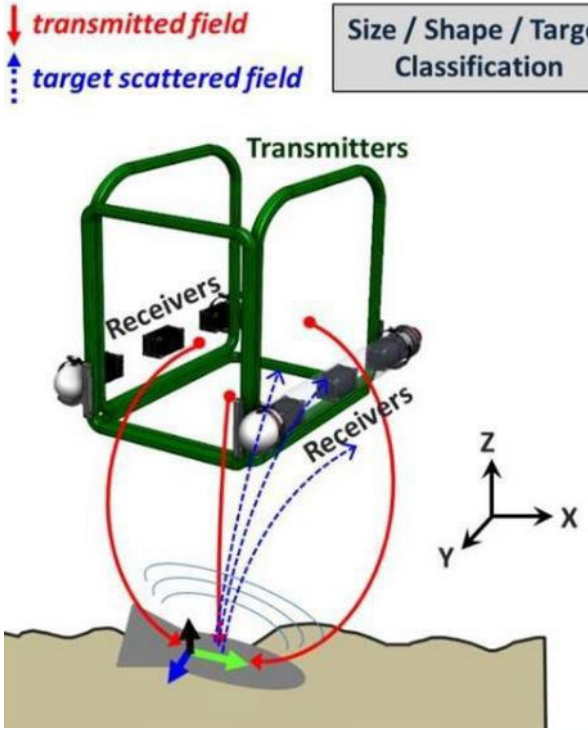
- *Limited in-water demo conducted*

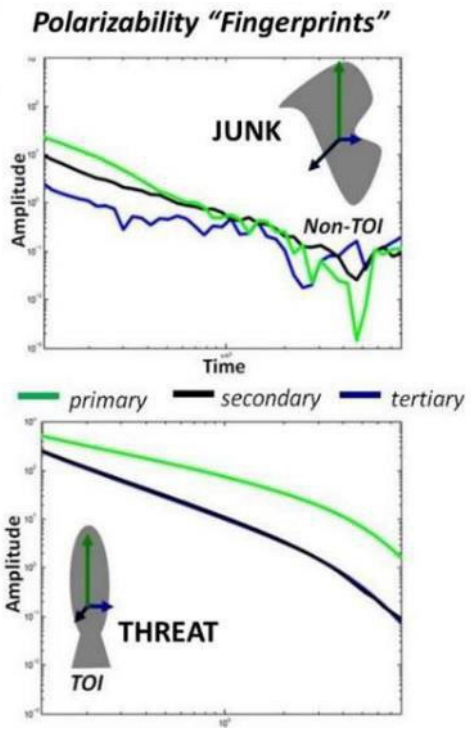
Task 5. Transition Assessment



ROV+APEX 3DEM Integration Design







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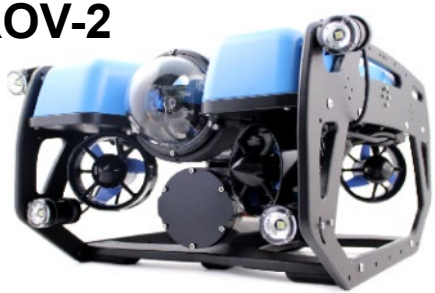
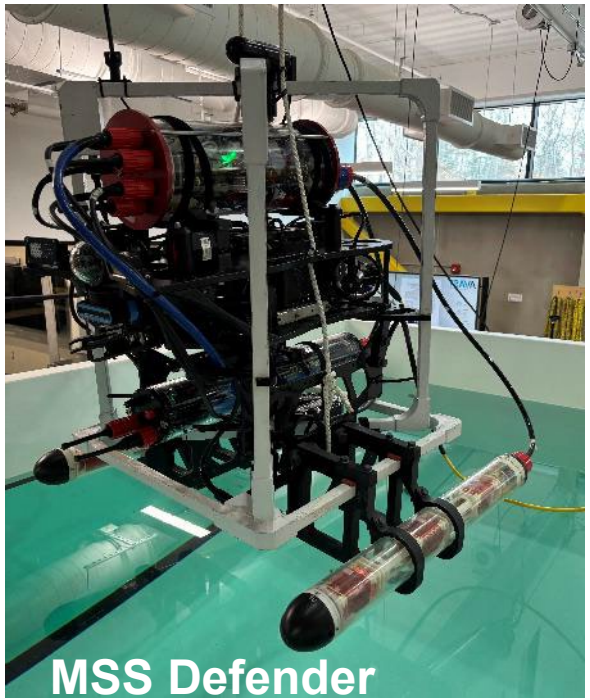
Transition BROV to MSS Defender ROV

BlueROV-2



MSS Defender



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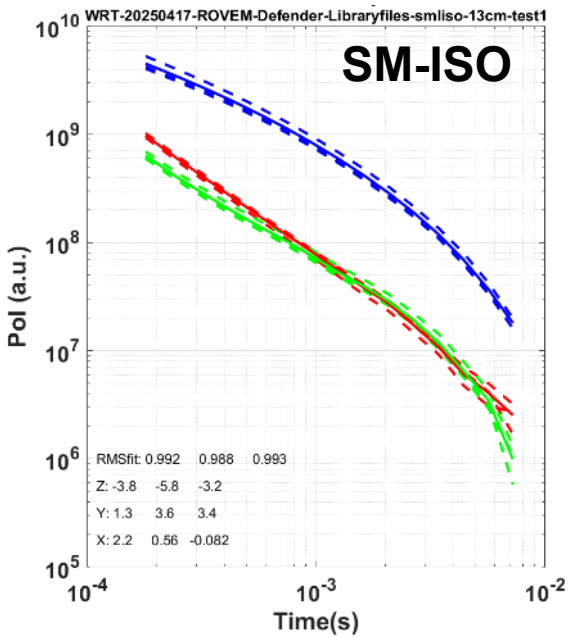
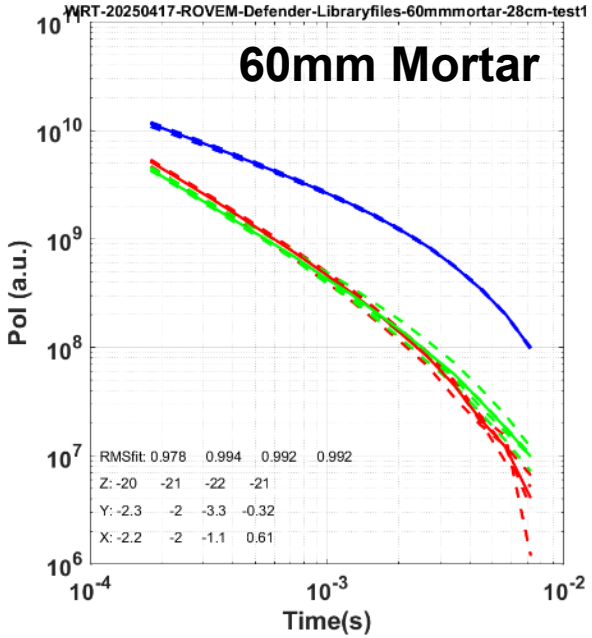
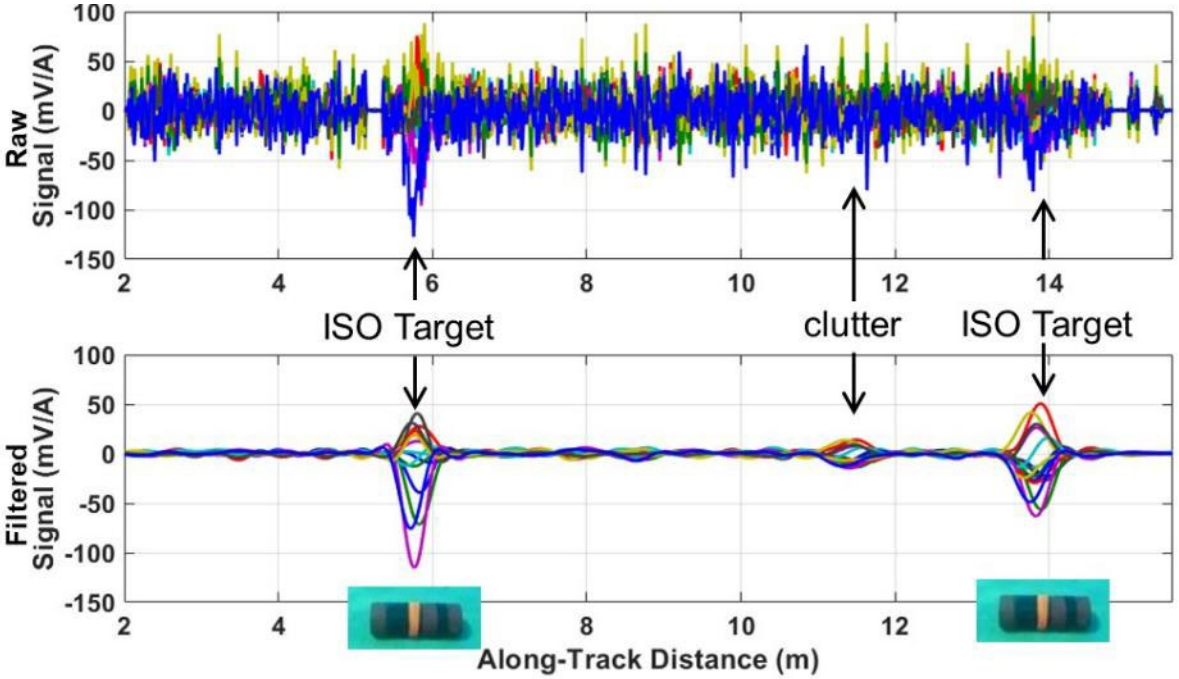
Defender ROV-EM Validation

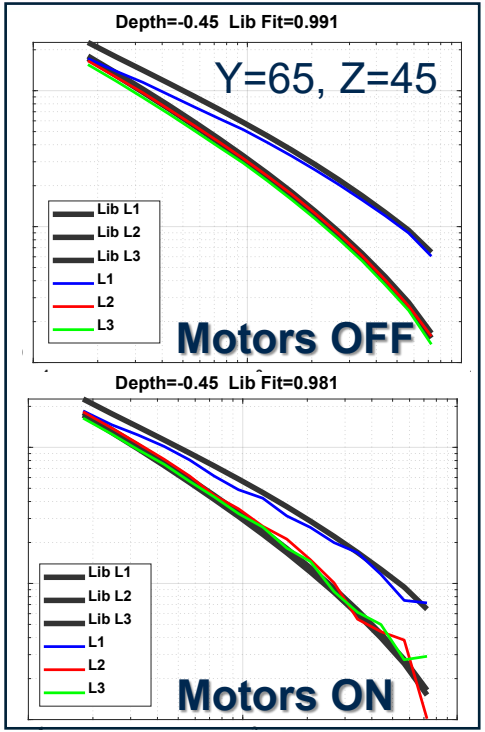




ESTCP

Defender ROV-EM Validation





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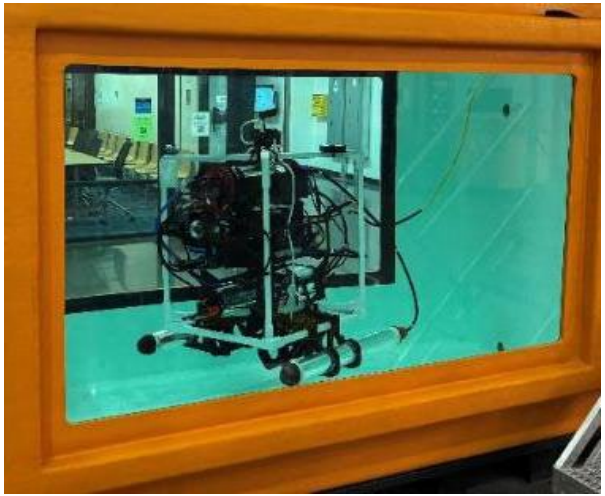
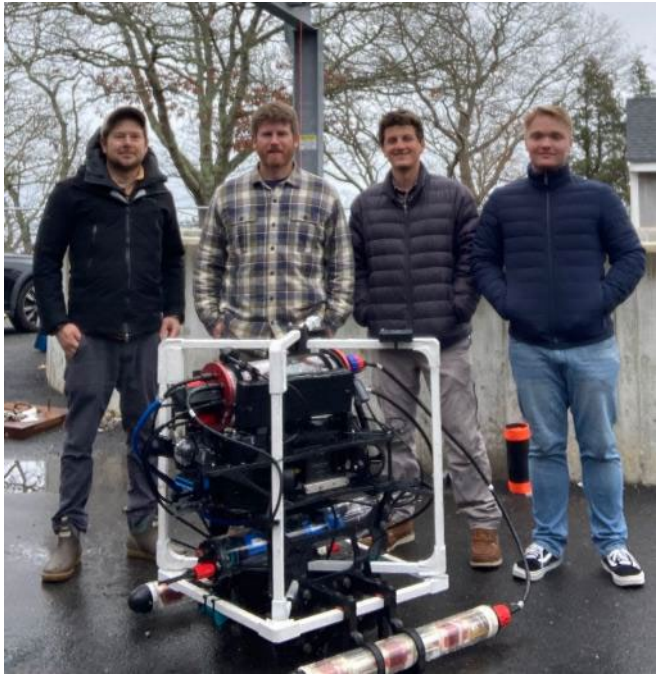
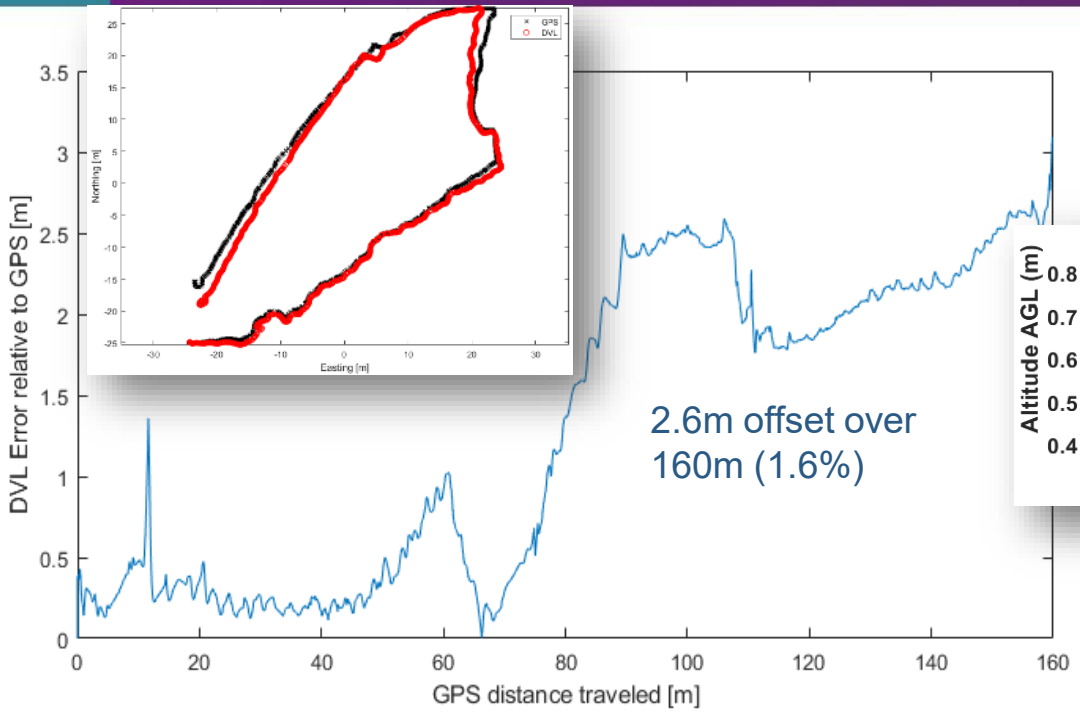
Defender ROV-EM Trim & Balance

- UNH & WHOI Tanks
- Hydrostatic Trim/Bal
- Hydrodynamic Proveout

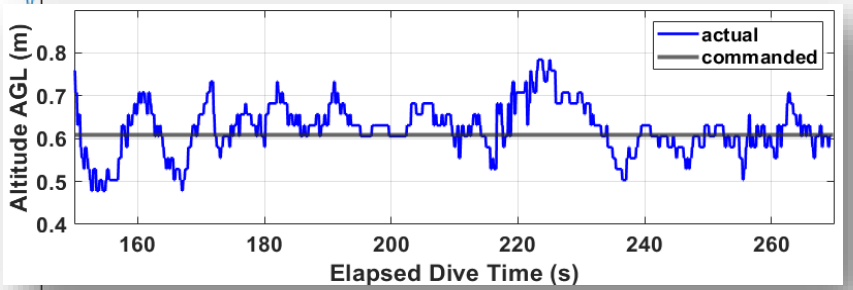




Nav/Pos & Bottom Tracking



- DVL-INS Heading Changes
- Heading Errors ~ 1-2% DT



- Bottom Tracking Using DVL
- STD = +/- 5.8cm
- Max Deviation = 17cm

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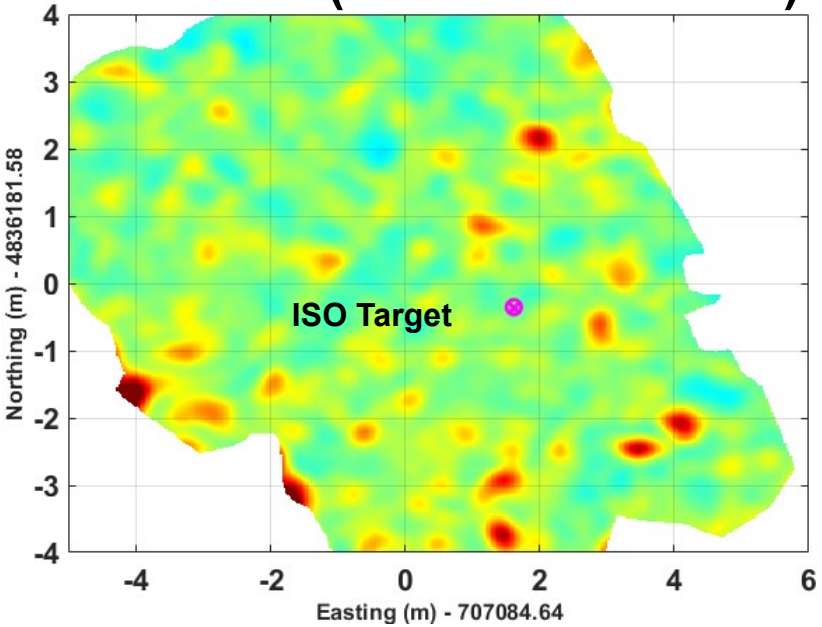
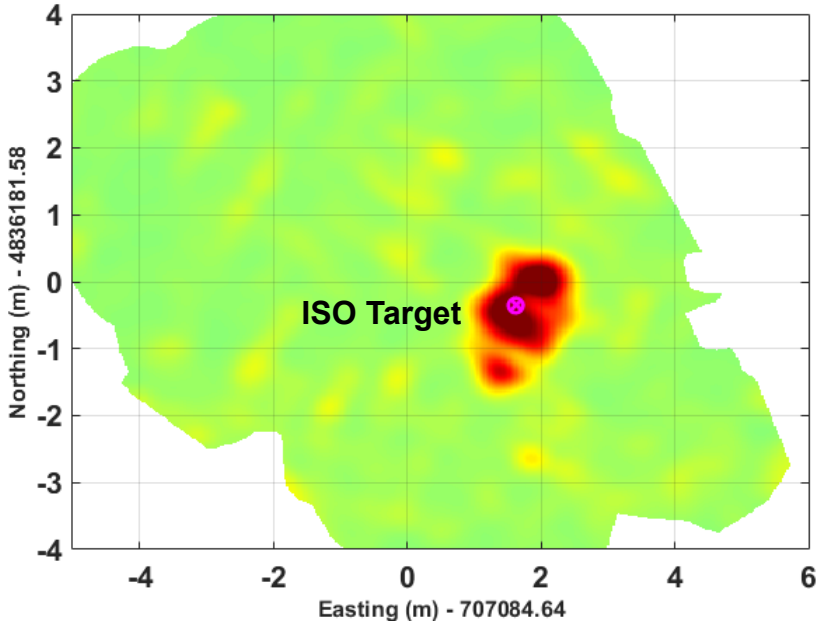
In-Water Engineering Tests

Raw Data (ROV Motor Noise)



Filtered Data



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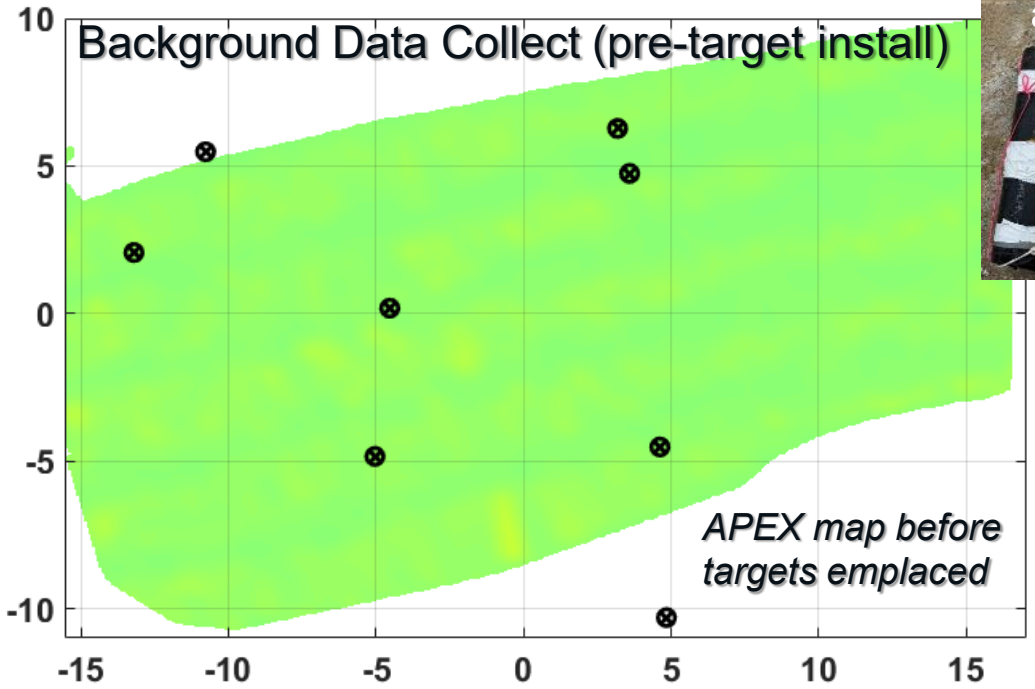
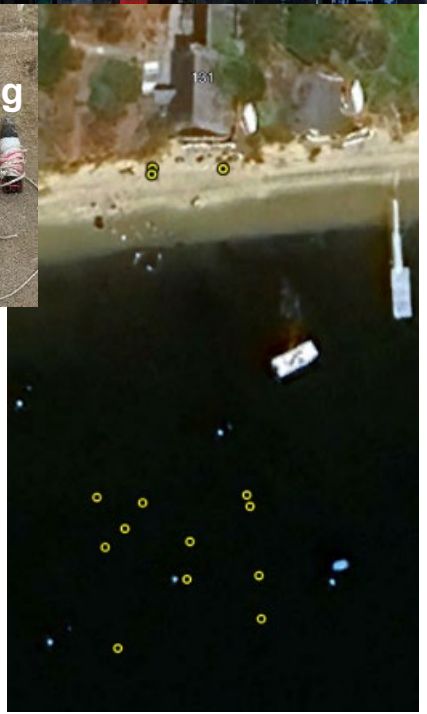
In-Water Full Scale Testing



a) XL-ISO
b) 155mm
c) 105mm HEAT
d) LG-ISO
e) 81mm Mortar
f) MED-ISO
g) 60mm Mortar



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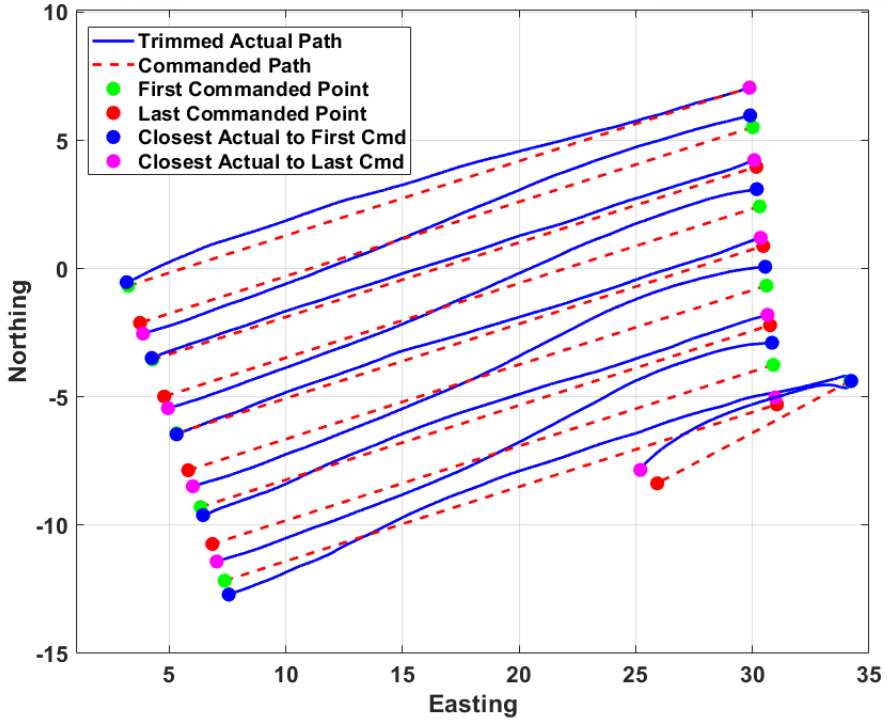
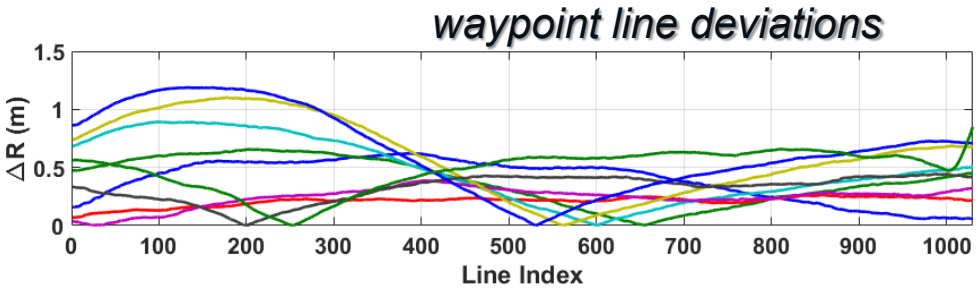
WHITE RIVER

TECHNOLOGIES

In-Water Full Scale Testing





- Waypoint line deviations from commanded
- Line spacing 1.2m
- Mean ΔR=0.38m, Max ΔR = 1.24m
- Tether catenary affects waypoint line track
- Analyzing heading drift influence on errors

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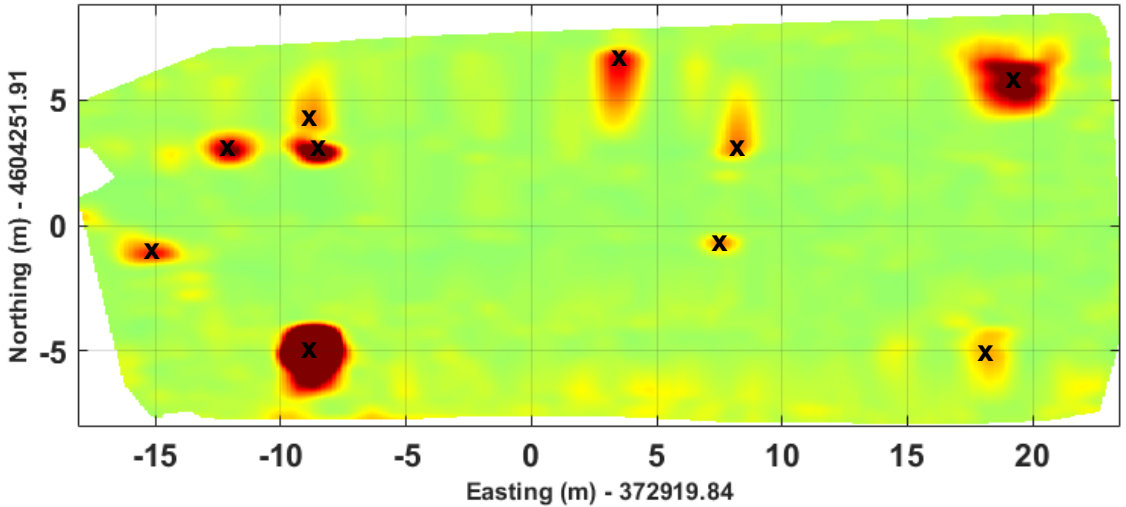
In-Water Full Scale Testing

- Filtered dynamic data reveal target detections
- Line track and coverage precision needed to improve anomaly resolution (smearing)



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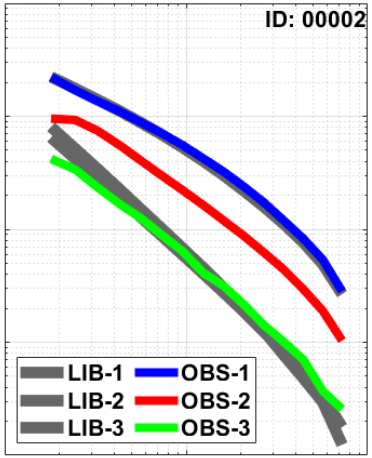
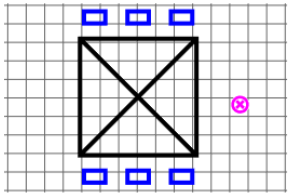
In-Water Full Scale Testing

MED-ISO

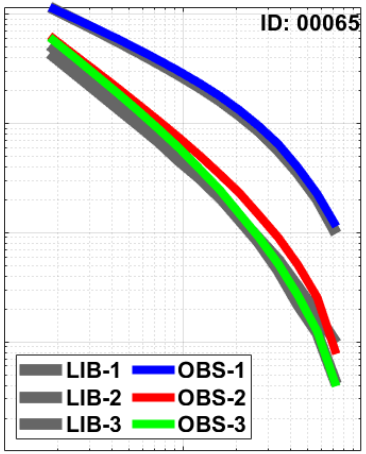


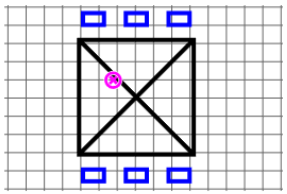


Classification Result

Best Match = MED-ISO
Library Match = 84.9%
Model Fit = 83.4%
Location = -4.1, 55.1 cm
Depth = -4.5 cm

60mm Mortar



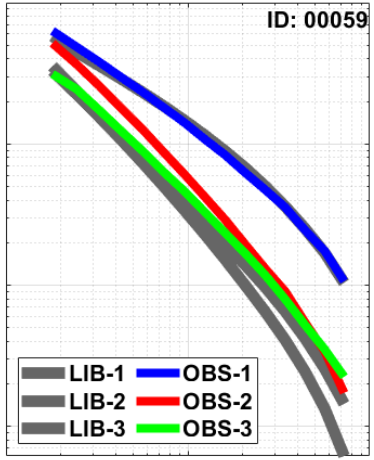


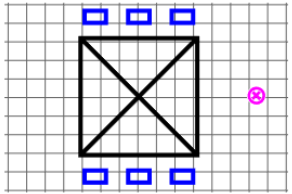
Classification Result

Best Match = 60mm Mortar
Library Match = 86.5%
Model Fit = 96.1%
Location = 9.3, -12.7 cm
Depth = -2.1 cm

In-Water Full Scale Testing

LG-ISO

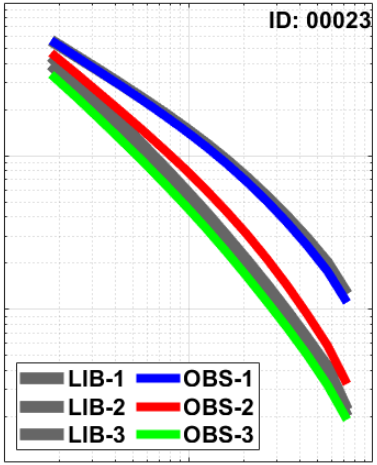


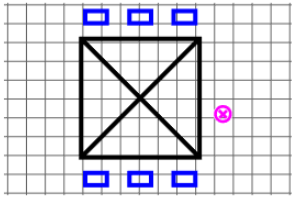


Classification Result

Best Match = LG-ISO
Library Match = 91.2%
Model Fit = 80.2%
Location = 0.5, 63.4 cm
Depth = -17.5 cm

105mm HEAT



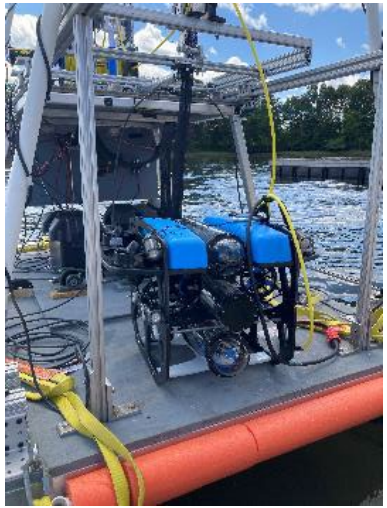


Classification Result

Best Match = 105mm HEAT
Library Match = 88.1%
Model Fit = 89.8%
Location = -8.5, 44.0 cm
Depth = 4.7 cm

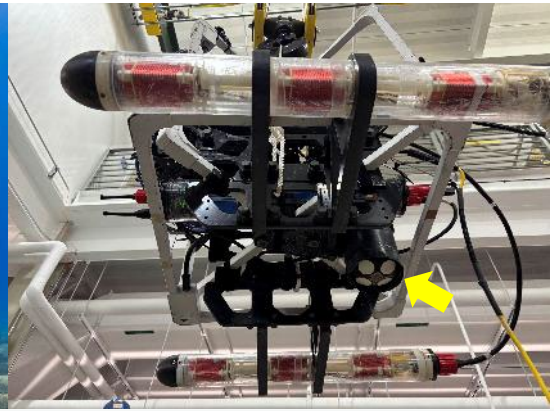
ASV Integration Design

- Propulsion Control
- Station Keeping
- Autonomous Path-planning
- Tether Tensioning System
- ROV Positioning System
- ROV Launch & Recovery



Issues

- UGPS SBL positioning not stable enough for autonomous surveying
- MEMS INS-aided DVL (Nortek) heading errors observed when APEX Transmitters are ON prior to sufficient DVL lock – working with VideoRay and GSSIQ (EODWorkspace) to investigate



Unit	Accuracy	INS?
WaterLinked A50	1 or 0.1%	Y
Cerulean ST 650	1%	N
Nortek DVL 1000	0.3%	Y
Nortek Nucleus 1000	0.3%	Y

Next Steps

- Investigate INS-aided DVL Calibration Prior to APEX TX ON
- Improve waypoint navigation for dynamic ROV-EM AGC
- Dockside ROV-EM in-water tests (Lake Pinneo, NH)
- Demonstration Plan revision (as needed)
- Execute limited demonstration at Waquoit Bay, Massachusetts
- Pursue alternative direct mount on Defender and/or SeaEye Falcon
- Implement new electronics bottle (77% smaller) & modular MAG payload (via NAVSEA MESR program)

Technology Transfer

1. **Production Transition Assessment**
   - Define operating envelope for full-scale implementation / operational concepts
   - Cost models: 1) “wet” lease option, 2) lease/contract option
2. **Outreach Products & Information Dissemination**
   - *SERDP Webinar (NOV 2024), MARELEC & SAGEEP Presentations (APR 2025)*
   - Pilot study use-case description (“sample problem”)
   - Complexities of ROV-based AGC White Paper (submitted to SEMS)
   - Training and information sessions (e.g., NAOC, M2S2, SAGEEP)
   - Social media posts (via SERDP-ESTCP prog. office)
3. **Govt/Commercial Demonstrations**
   - Collaboration with NAVFAC & USACE on Demonstrations / Live Site Transition Pilots
   - Demonstrations with interested prime contractors → direct transition

BACKUP MATERIAL

These charts are required and will be used by the Program Office but may not be presented.

MR22-7454: Highly Integrated Autonomous ROV-based 3DEM for Underwater AGC

White River Technologies, Inc.

Technology Focus

- *Cost-effective methods for highly-integrated Remotely Operative Vehicles and underwater 3D EM technology for shallow water UXO site assessment*

Demonstration Sites

- *Demo Site: Sequim Bay UXO Test Area*

Demonstration Objectives

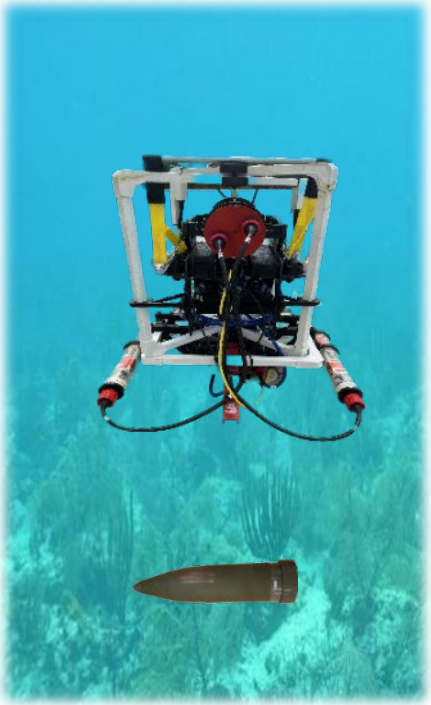
- *Implement and demonstrate integrated inspection-class ROV + 3DEM technology to address seabed UXO surveying*

Project Progress and Results

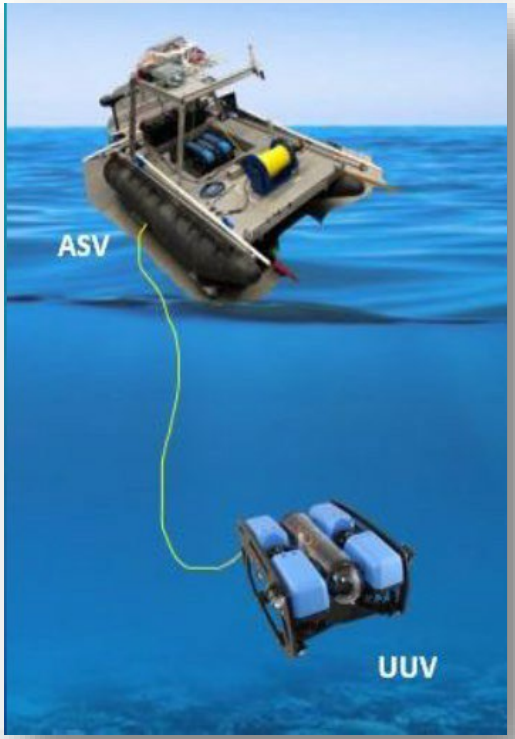
- *Completed integration design and performance predictions*
- *Verified prototype ROV-EM unit during in-water tests*
- *Assessed and quantified underwater positioning (UGPS) accuracy*
- *Initiated Autonomous Surface Vehicle deployment configuration*

Implementation Outlook

- *On-track to complete modifications and optimization toward initial open water tests with integrated UGPS, ASV, and ROV-EM system*



Demonstration System Technology



- **GPS:** Use when **Vehicle on the surface**
  - Constant GPS updates
  - Minimal navigation error build up
- **USBL:** Use when **Vehicle is below surface, no bottom lock**
  - Topside GPS combined with USBL establishes vehicle location.
  - Less precise navigation
- **DVL:** Use when **Vehicle has bottom lock**
  - No GPS update
  - Navigation error builds up over time

Plain Language Summary

- Shallow water UXO sites (<5-10m water depth) lack effective methods to detect and classify individual munitions, especially where bottom conditions challenge acoustics
- Previous ROV-based classification techniques suffered from hydrodynamic maneuverability and efficient mobilization, positioning, and survey control
- Cost-effective methods that apply to a wide range of nearshore, riverine, and lacustrine sites needed to fill gap between land-based AGC and offshore surveying methods

Action Items

1. Submit White Paper on complexities of AGC on ROVs (submitted to SEMS)
2. Complete Interim Report on Underwater GPS Short-baseline acoustic positioning assessment (submitted to SEMS)
3. Complete Demonstration Plan draft (submitted to SEMS)
4. Updated expenditures in SEMS (completed for FY24)

Impact to DoD Mission

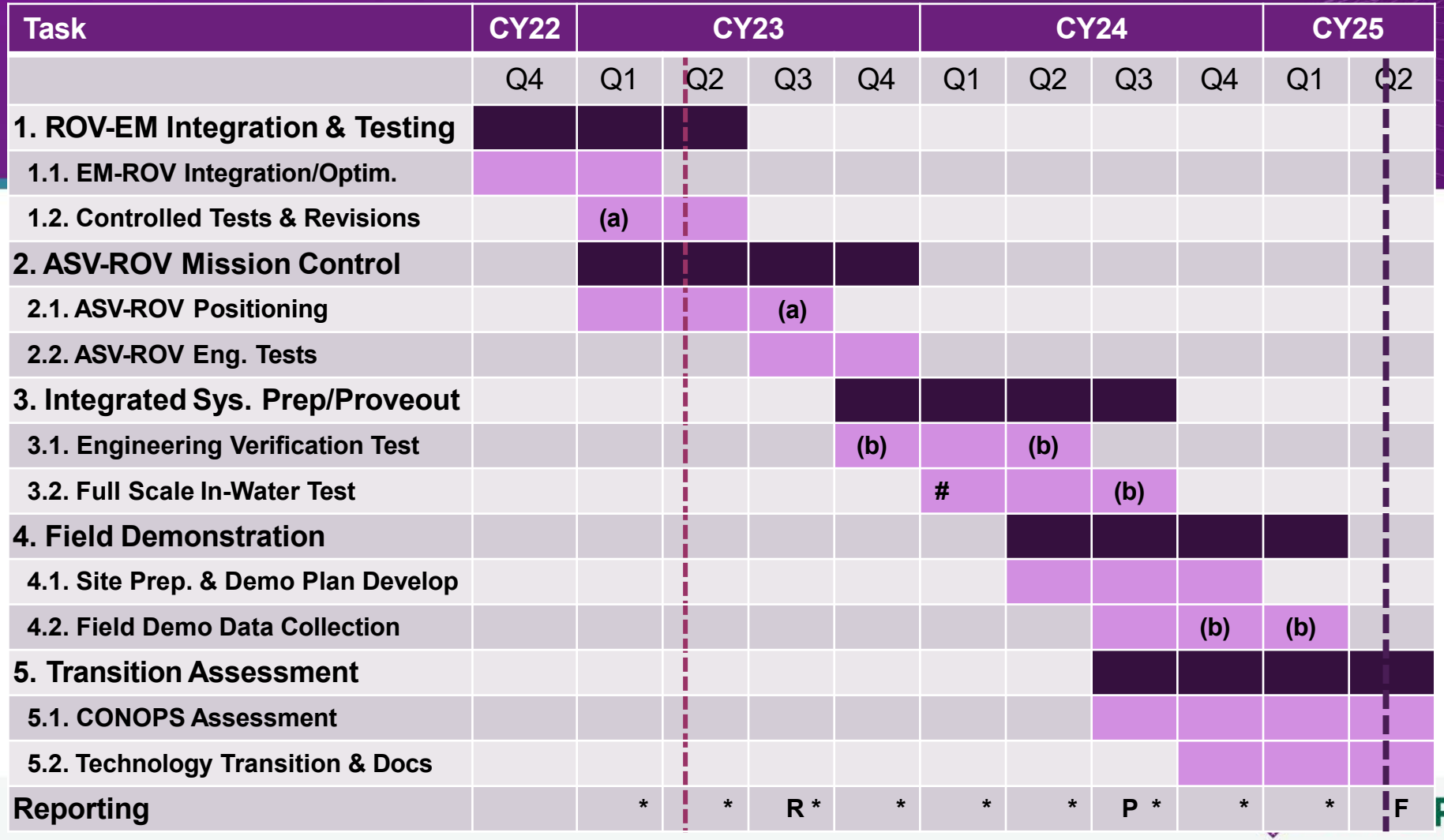
- The Program Office wants to convey the significance of your research to DoD leadership, Congress, and the broader community.
  - What's the most impactful thing that's happened since the last time you presented your work to us?
  - Why is this important?
  - How is your project advancing DoD capabilities?
  - Include high quality images

Publications

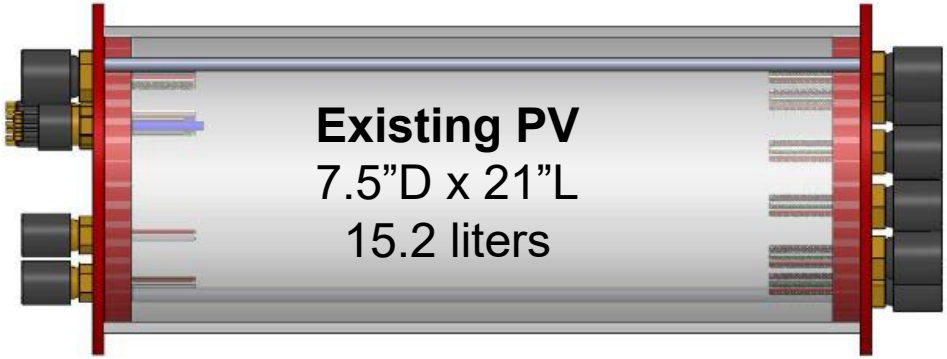
- Provide a list of all publications, patents, awards, etc., resulting from this work.

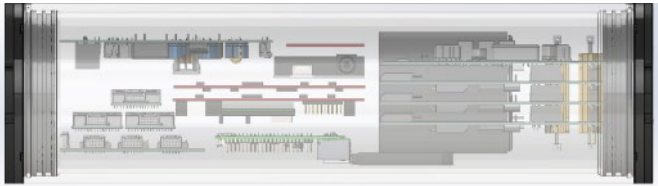
Literature Cited

- Provide a list of all the published work you cited in the presentation.

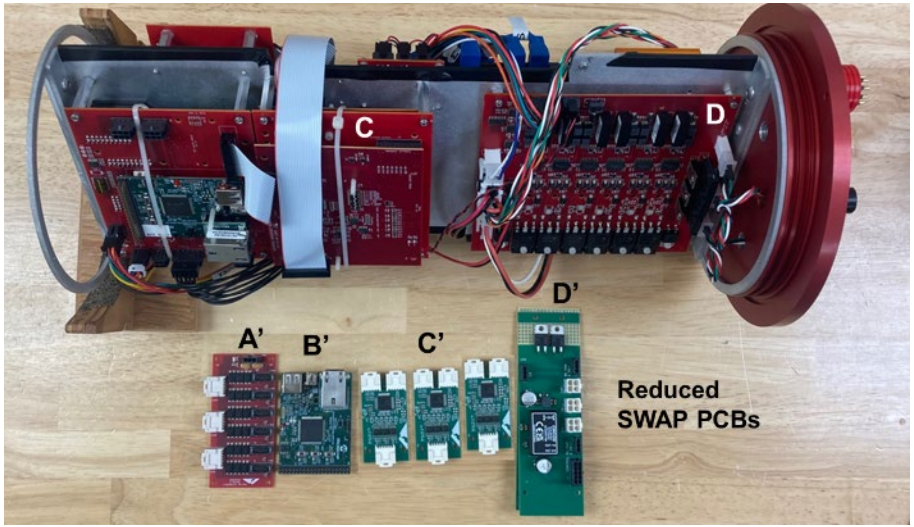

Task
CY22
CY23
CY24
CY25
Q4
Q1
Q2
Q3
Q4
Q1
Q2
Q3
Q4
Q1
Q2
1. ROV-EM Integration & Testing
1.1. EM-ROV Integration/Optim.
1.2. Controlled Tests & Revisions
(a)
2. ASV-ROV Mission Control
2.1. ASV-ROV Positioning
(a)
2.2. ASV-ROV Eng. Tests
3. Integrated Sys. Prep/Proveout
3.1. Engineering Verification Test
(b)
(b)
3.2. Full Scale In-Water Test
#
(b)
4. Field Demonstration
4.1. Site Prep. & Demo Plan Develop
4.2. Field Demo Data Collection
(b)
(b)
5. Transition Assessment
5.1. CONOPS Assessment
5.2. Technology Transition & Docs
Reporting
* * R * * * * P * * F

Electronics Upgrade (SWAP Reduction)



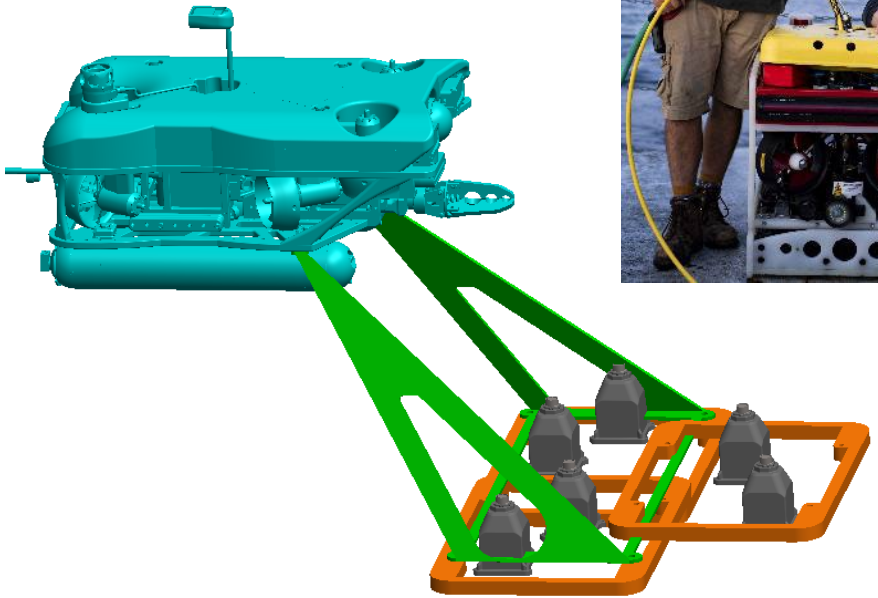


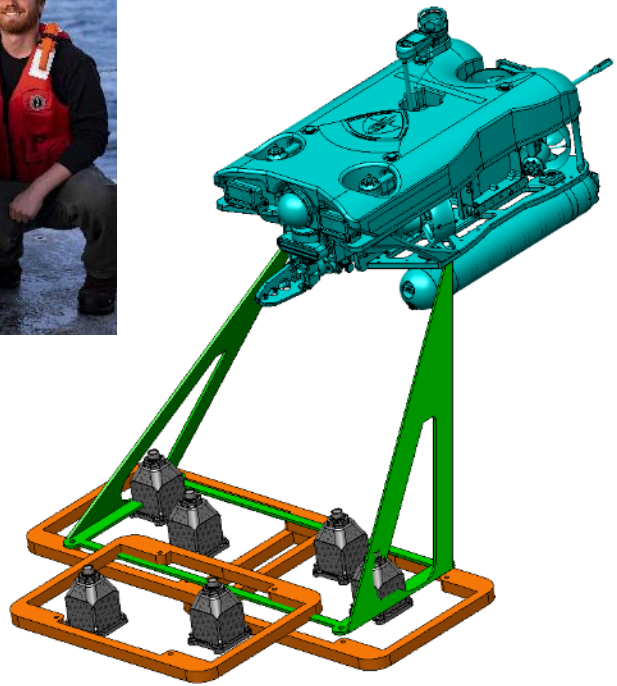
New PV
4”D x 16.5”L
3.4 liters



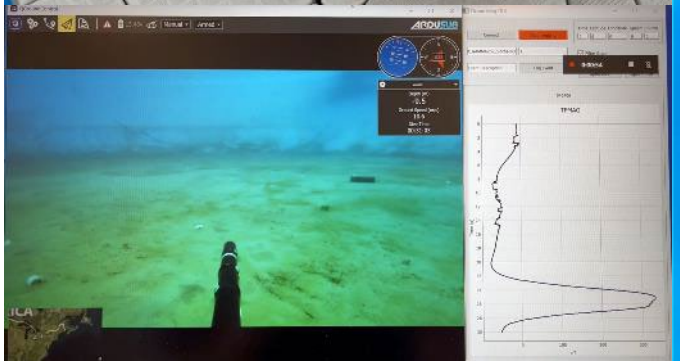
- ***>77% decrease in size (vol.)***
- ***Validated on APEX cart unit***

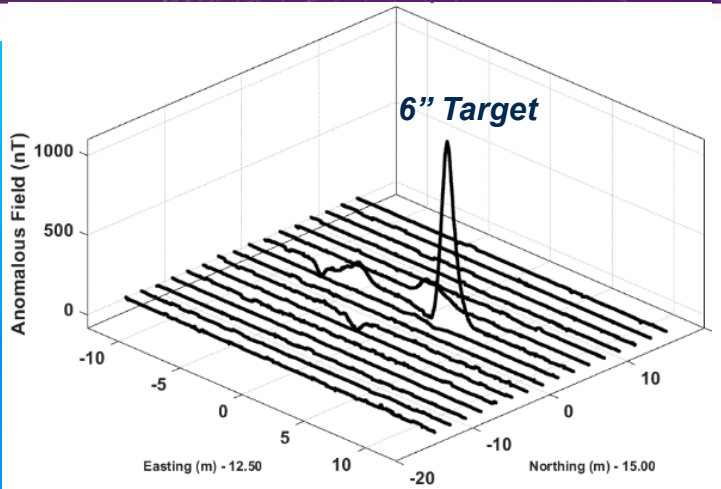
ROV-EM Direct Mount Variant





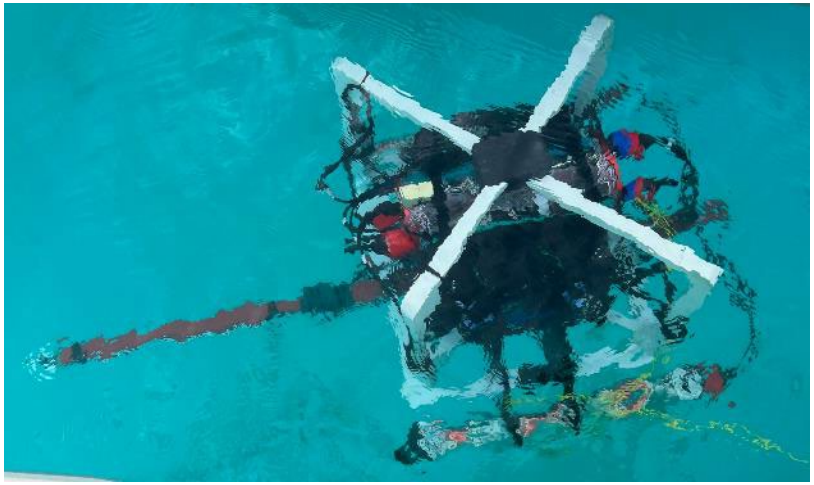
ROV-MAG Mapping System

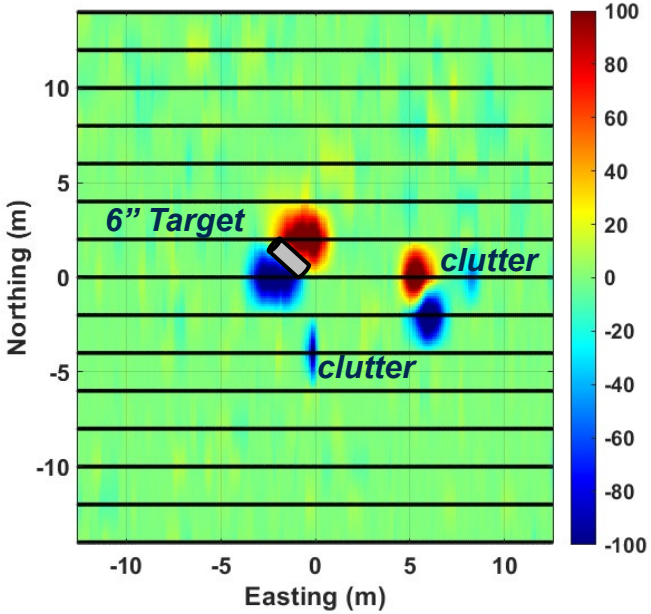




ESTCP

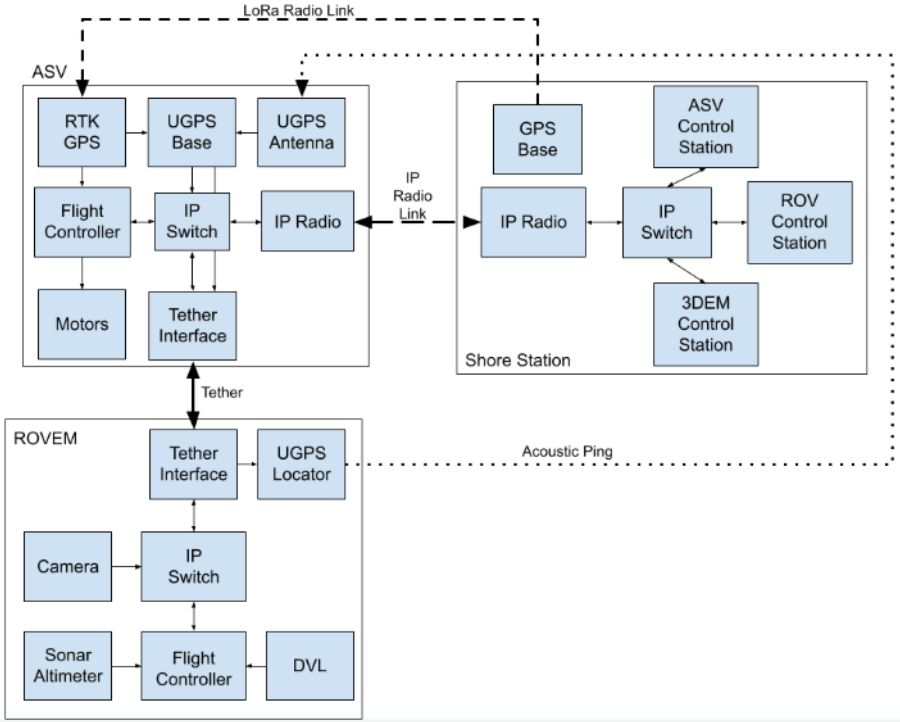
ROV-MAG Mapping System

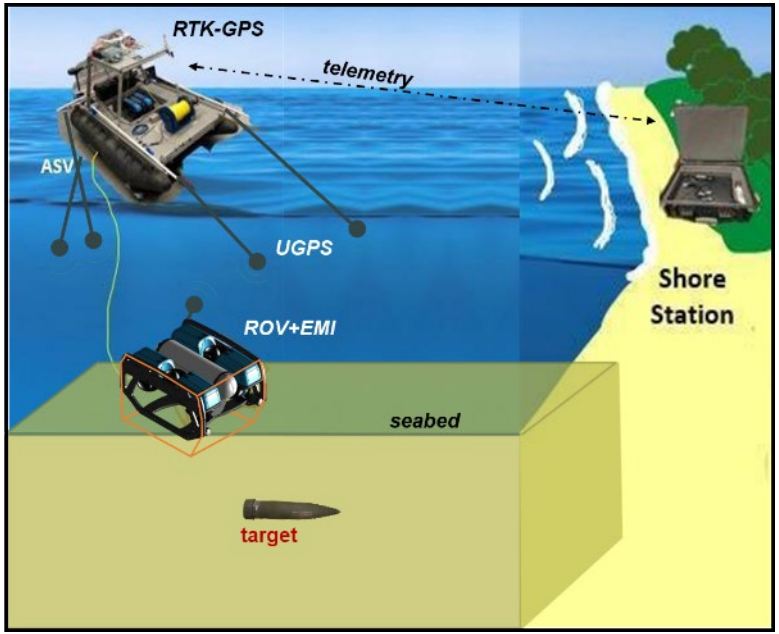




ESTCP

ROV-EM Integration





ESTCP