Establishment of a Surfzone and Very Shallow Water Munitions Response Test Range

Project Number: **MR25-AZ-8606**

Principal Investigator: **Dr. Spicer Bak**

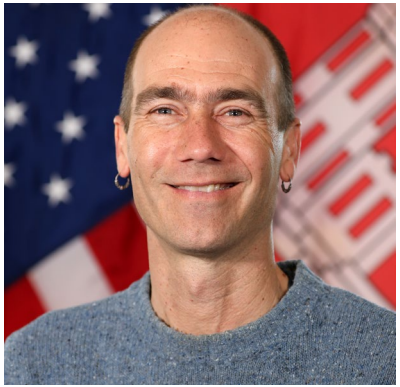
PI's Organization: **US Army Engineer Research and Development Center**

In Progress Review Meeting

13 January 2026

Project Team

Dr. Spicer Bak
USACE ERDC



Mr. Patrick Dickhudt
USACE ERDC

Mr. Jason Pipes
USACE ERDC

Mr. Andrew Schwartz
USACE HNC

Contractor: Chesapeake Bay Divers

Bottom Line Up Front

- ERDC team executed deployment of targets for performer 1 (WRT) the last 2 weeks of October 2025
- Performer 1 conducted technology demonstrations 3 – 7 Nov 2025
- ERDC recovered all but 2 targets 17 – 21 Nov 2025

Background/Proposed Work

Pilot

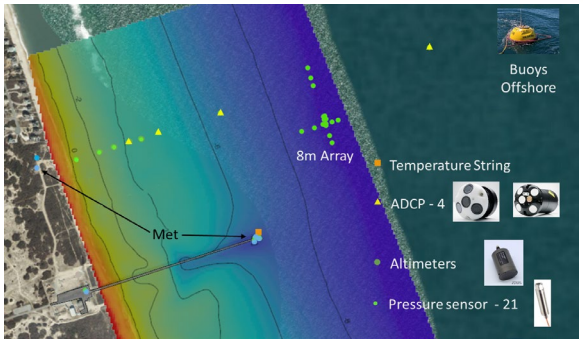
Deploy

Host

Experiment

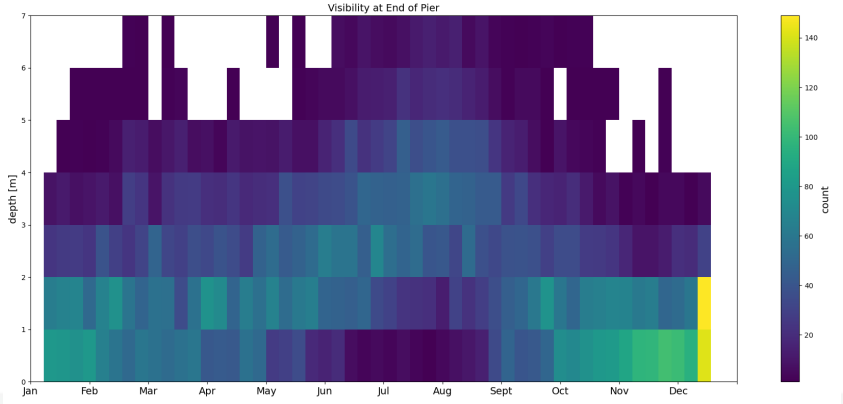
Site Description

- The FRF is a surfzone observatory with a rich historical dataset that can inform experimentation plans



- Wave, current, and MET observations available to help quantify experimental conditions

- A 25+ year Secchi disk record provides information on background optical properties available at our site.



ESTCP

Site Description: Specialized Equipment

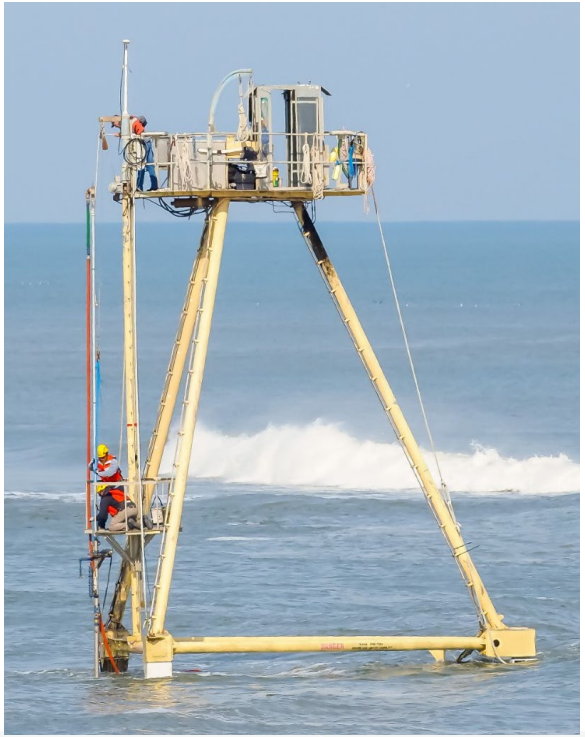
- CRAB
  - 40’ tall
  - Operating conditions: < 2m waves
  - Speed: 1 kt
  - Lifting capability: 1,000 lbs
  - Positioning capability: RTK GNSS – precision/stability in breaking waves
- LARC
  - Amphibious support vessel
    - 4 vessels, 2 with survey capability, 2 rigged for lifting / deck operations
  - Speed: 6 kts
  - Lifting capacity: 500 lbs
  - Positioning capability: RTK GNSS
  - Payload: Norbit 400khz MBES 256 beam

Technical Approach: Method Development

- Information Gathering
  - Discuss methods with previous sites, prior performers
- Pilot deployment
  - Test different deployment/localization/anchor methods
  - Quantify accuracy/uncertainty in localization methods
    - Place then reoccupy multiple times
  - Determine efficiency in planning (how many targets can we place per day)

Technical Approach: Deploy

- Team will use CRAB to install targets
- Sediment will be softened with water pumped
  - from ocean → top of crab → through 2” pipe to soften sediment
  - Method capable of putting 6” diameter pipe 15’ into sea floor
- Place target in soft sediment
- Target position will be taken with long dwell RTK GNSS
  - Stadia Rod (9m) held at CRAB crow’s nest
  - Diver grabs base of rod, places it on target
  - Taps on rod, Crow’s nest operator takes 30-60s (@10 hz) GNSS positional point
  - Crows nest operator taps on rod once point is taken
  - Diver moves on to next task



Technical Approach: Experiment

- Team will host experimenters
- Visiting teams will have access to:
  - Staging area
  - Heavy equipment
  - Meeting rooms (as available)
  - Fabrication shop
  - All-terrain vehicles (ATVs)
  - Sun protection tents
- Available to close beach down as needed
- Optional capability: have divers/CRAB re-establish target positions ($$)

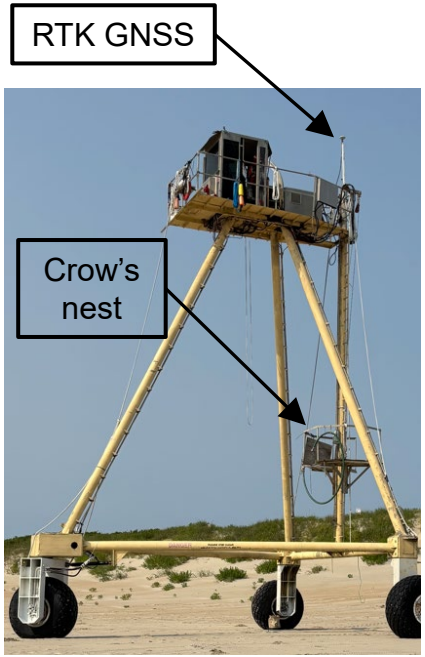
Technical Approach: Recover

- Team will use magnetometer to identify area
- CRAB will be used to jet near target (as necessary)
- Divers will identify target in soft sediment
- Target position will be taken with RTK GNSS
  - Stadia Rod (with inclinometer) held at CRAB crow's nest
  - Diver grabs base of rod, places it on target
  - Taps on rod, Crow's nest operator takes GNSS positional point
  - Crows nest operator taps on rod once point is taken
  - Diver moves on to next task
- Recovery will be weather dependent (divers on standby)

Background/Proposed Work
Pilot
Deploy
Host
Experiment

Pilot 1 – Objectives

- Preparation
  - Demonstrate burial concepts / methods with divers on beach
- Deploy Anchors and Targets
  - Verify efficiency of anchor installation methods
  - Determine whether to install daisy chains of targets or single target per anchor*
  - Determine time to deploy each munition (number of munitions per day)*
  - Determine optimal depth to bury munition
- Survey / Localization
  - Quantify accuracy / uncertainty in localization methods
- Recovery
  - Verify ability to move off of target and return accurately
  - Determine time to recover single anchor / multiple anchors
  - Determine relative efficiency of using tag line for recovery



* Also goals of Pilot 2

Pilot 2 – Objectives

- Overall Objective
  - Demonstrate burial of multiple targets and anchors to determine repeatability, uncertainty in methods, and nominal number of deployments per day for full experiment
- Deploy Anchors and Targets
  - Verify efficiency of anchor installation methods
  - Determine whether to install daisy chains of targets or single target per anchor
  - Determine time to deploy each munition (number of munitions per day)
  - Determine optimal depth to bury munition
- Survey / Localization
  - Quantify accuracy / uncertainty in localization methods
- Recovery
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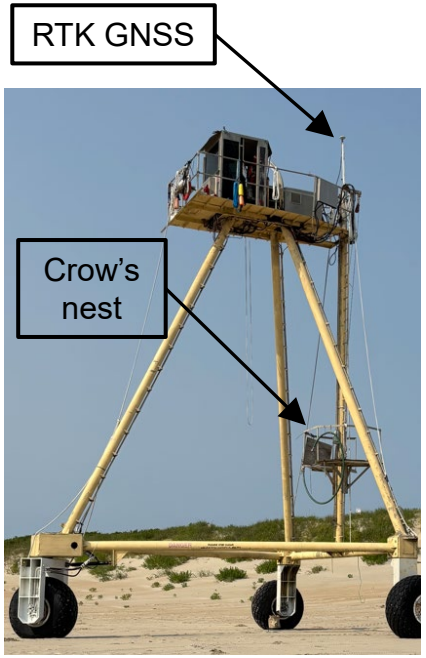


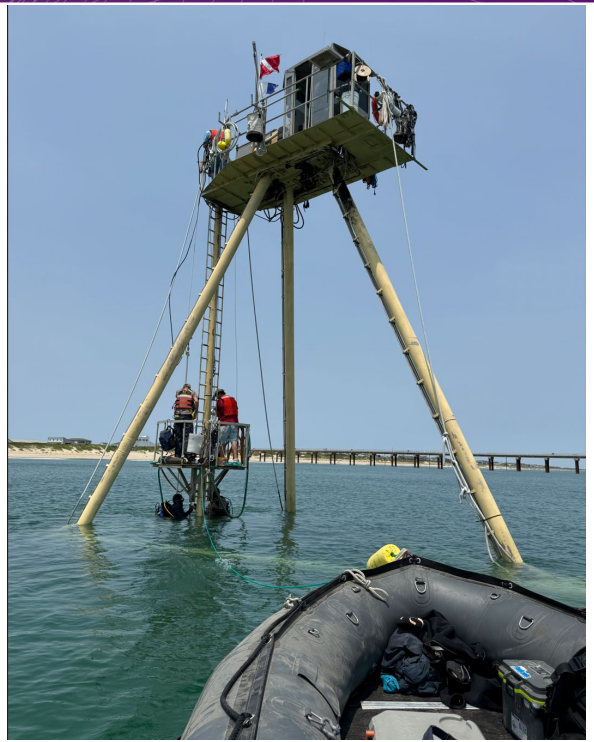
Pilot 1 – Results

- Day started with dry beach deployments with divers to get familiar with methods, seed size, and project needs

- On water time approximately 1000 – 1600 (6)
- Wave conditions Hs < 1 foot
- Wind conditions u_{30} < 5 kts
- Water visibility > 15 ft

PERFECT WEATHER CONDITIONS

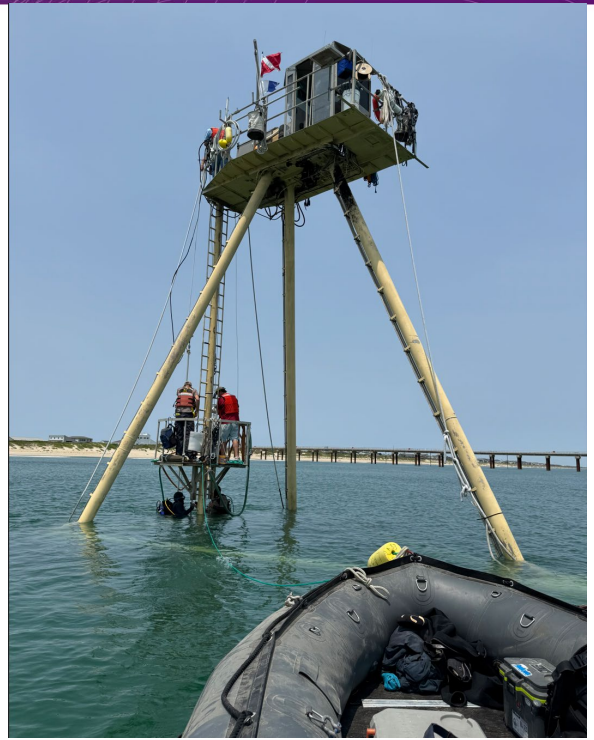
- Deployed small and large targets
- Team deployed and recovered 5 targets varying:
  - Anchor type
  - Deployment method
  - Approach to localization



Pilot 2 - Results

- On water time approximately 1000 – 1600 (6 hrs)
- Wave conditions Hs < 1 foot
- Wind conditions u_{30} < 5 kts
- Water visibility > 10 ft
- Deployed small and large targets
- Team deployed and recovered 5 targets varying:
  - Anchor type
  - Deployment method
  - Approach to localization

PERFECT WEATHER CONDITIONS…AGAIN

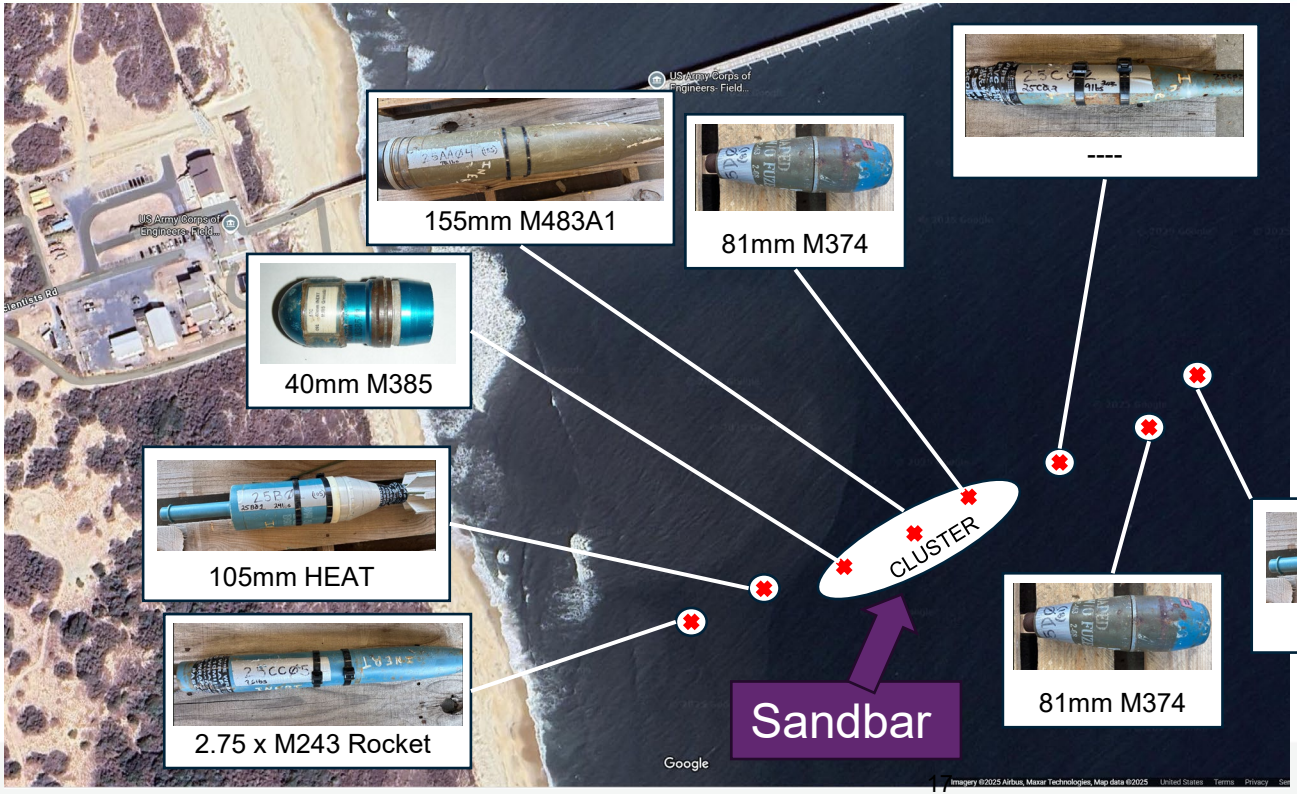


Technical Approach: Performance Objectives

- Performance objectives are centered around placement efficiency and precision
- Precision will be identified during the pilot test in which we identify a target multiple times in a short time window and analyzing range of positions acquired.

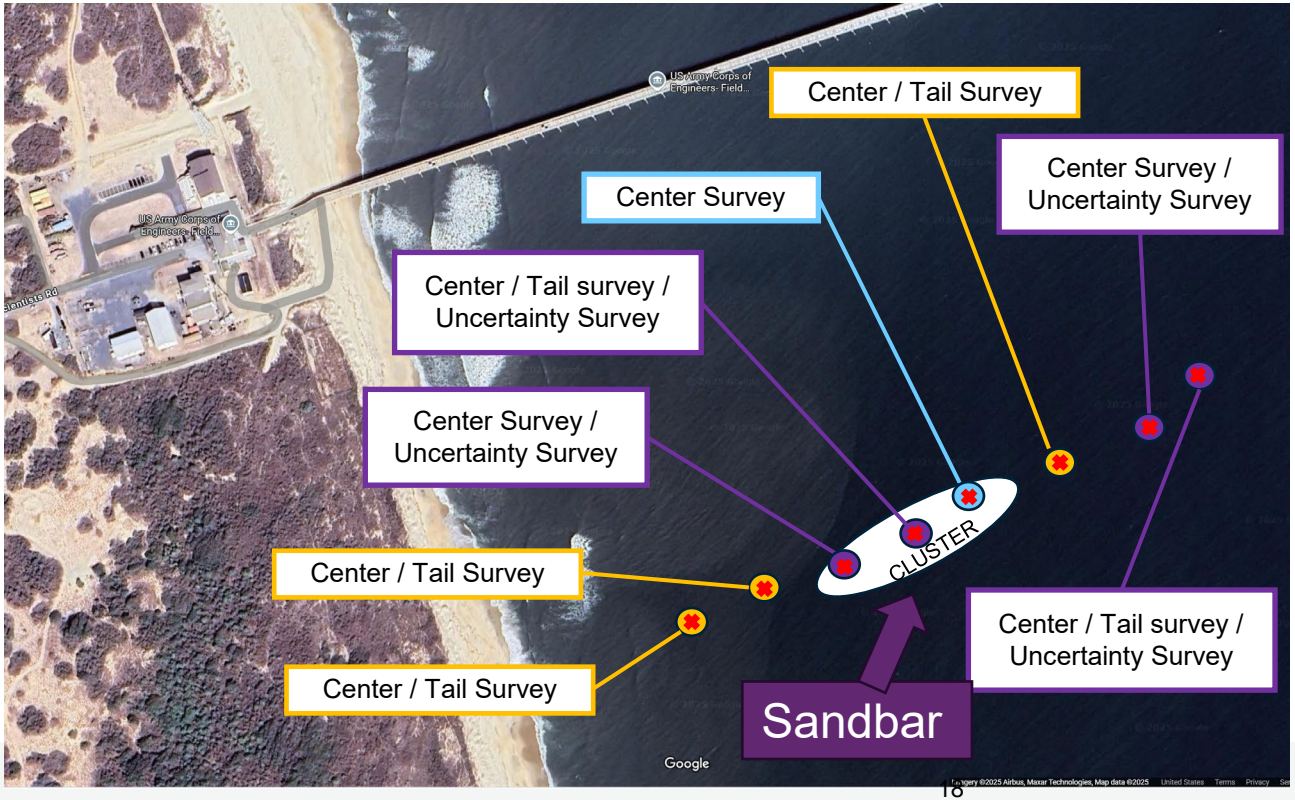
Performance Objective	Success Criteria
Precision in Localization	
Target Objective	< 10 cm in x, y
Threshold Objective	< 1 m in x, y
Efficiency in deployment	
Target Objective	>12 targets/day – targets on order of 10s of meters apart
Threshold Objective	10 targets/day – targets on order of several meters apart

Pilot 2 – Target Placement



- Single Targets
  - One target per anchor (except cluster)
  - All targets surveyed at time of placement
- CLUSTER
  - 155mm used as the center anchor
  - 3 targets tied together

Pilot 2 – Target Recovery / Survey



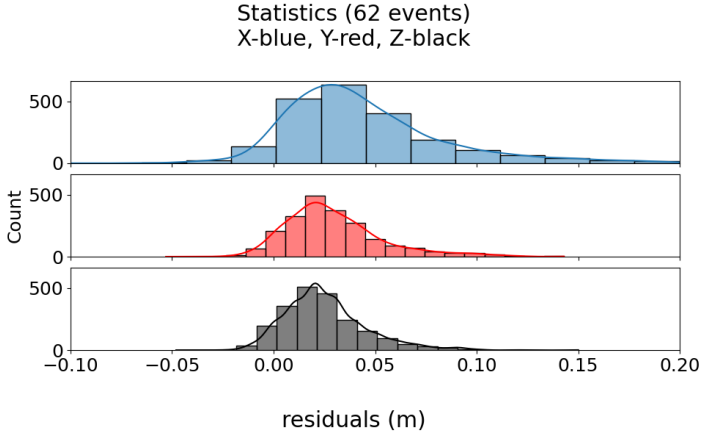
- Target Surveys
  - All targets were surveyed for position
  - 1 smaller target (blue) was surveyed at the center only
  - 3 larger targets (yellow) were surveyed at the center and tail
- Uncertainty Surveys
  - Targets were surveyed 5 times by surveying, reburying, then surveying again – 5 times total
  - 1 target (purple) was center survey only
  - 3 targets (purple) were surveyed at the center and tail

Technical Approach: Error Sources

- Error in localization is an aggregate of the following components:
  - Vehicle position: provided by RTK GNSS on vehicle
    - precision of placing vehicle <10 cm
  - Stadia rod has separate RTK GNSS
    - Precision of identifying stadia rod tip is $\sqrt{GNSS^2 + IMU^2}$ (assumed < 10 cm)
  - Diver placing rod on target
    - Targets can be small or large, placement might range from tip to tip creating uncertainty
    - We will work with divers pre-deploy to identify best way of capturing target location and pose information
  - Repeatability
    - Will be primary method for quantifying uncertainty in placement (for Diver localization approach)

Results to Date – Uncertainty

- **Methods**
  - Survey Rod with GNSS on Mast and bubble level, human focused
  - 30 – 60 s records x 5 repeats (1hz data unfortunately)
  - Done on 4 of 8 targets, Nose/tail when available, Large/small
  - X/Y identified by median position
    - Z identified by corresponding position to median X/Y
  - Residuals aggregated across 62 populations
  - Std deviation across all samples =>
  - 95% confidence shows X/Y uncertainty



σ_X = 0.029m -> **11.76** cm @ 95%

σ_Y = 0.019m -> **7.84** cm @ 95%

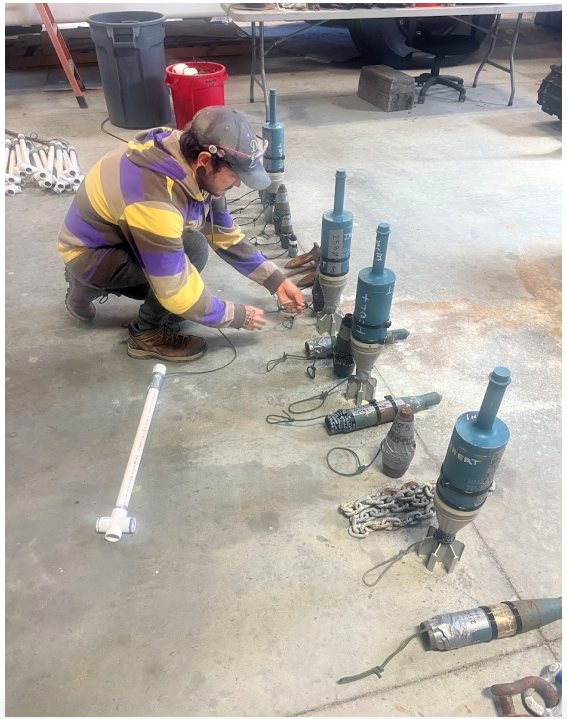
σ_z = 0.017m -> **6.97** cm @ 95%

Full Deployment Considerations
Time Optimization

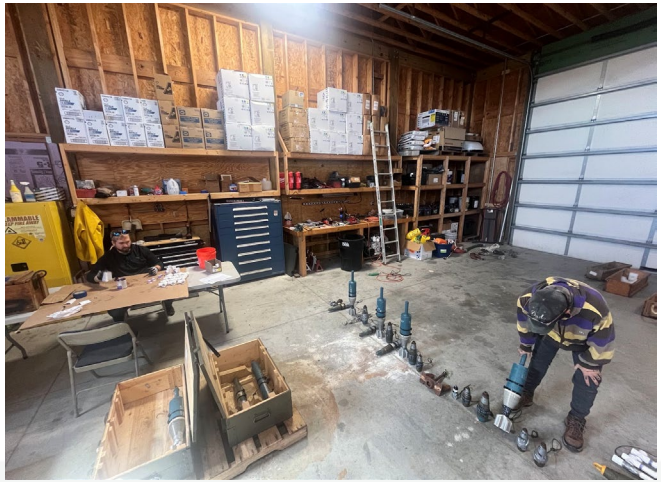
- Target deployment involved setting anchor, seed, and surveying in position
- Time per target (ideal conditions) ranged from
  - Deploy: 1 hour on first target to 18 minutes on last target
  - Recover: 17 min to 30 min
- Major time sink associated with moving, and locating with precision
- Time optimization gains come with
  - Relaxed accuracy in placement target (not sacrificing localization)
  - Strategic target placements that minimize precise placement on CRAB
    - Can’t avoid this on recovery (inherently taking longer)
  - Deployment Field somewhat optimized for placement while maintaining “random” placement

Background/Proposed Work
Pilot
Deploy
Host
Recover

Results to Date

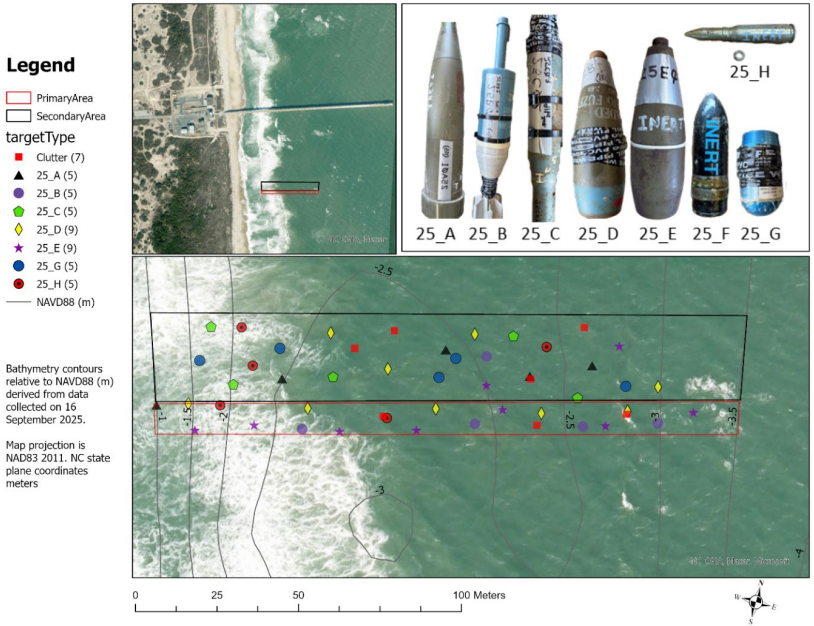


- All targets prepared in advance of field efforts week of 10/20/25; serial numbers, zip ties, "inert," and descriptions added.
- Wind and wave forecast finally conducive for ops!



Results to Date

- Tiered approach deployment plan
- Improved naming conventions to maximize efficiency during operations

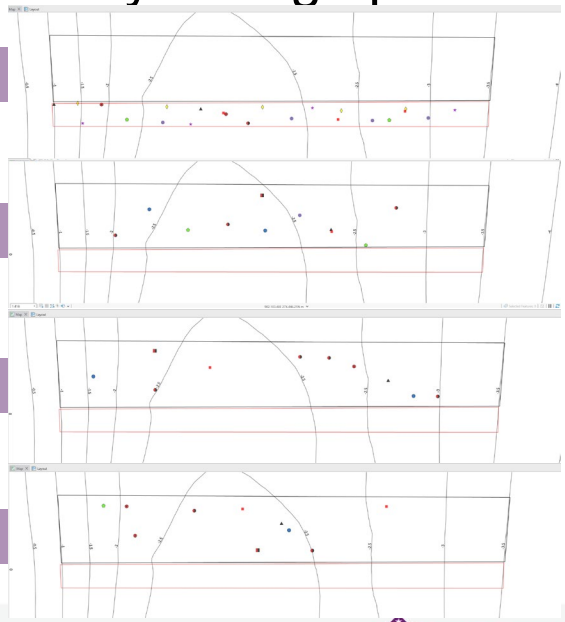


Tier 1 priority (20)

Tier 2 priority (10)

Tier 3 priority (10)

Tier 4 priority (10)



ESTCP

Deployed Targets

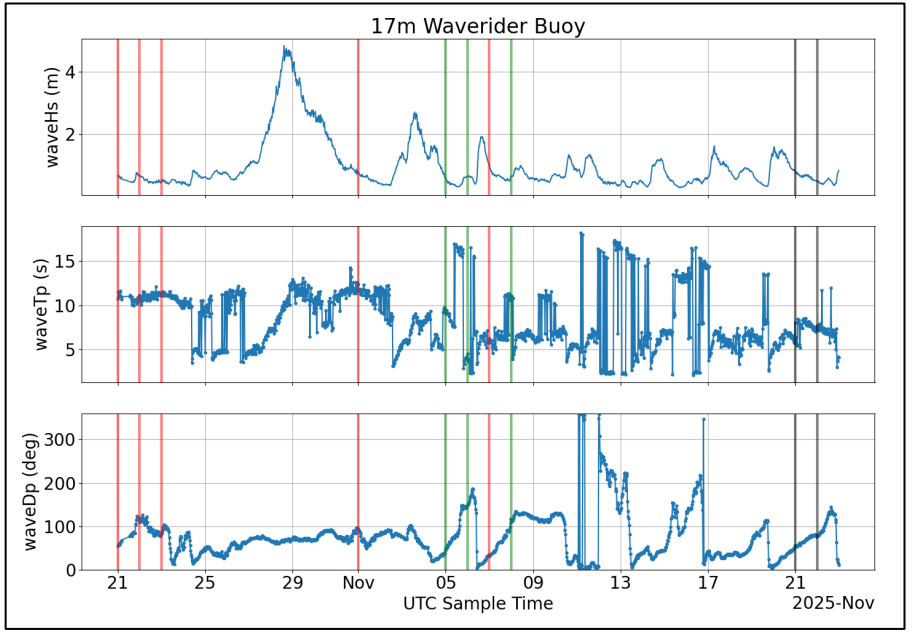
- Listed targets to deploy as TOI on right
- Included Small and Medium ISOs

Figure 2-1. Industry Standard Objects

	UXO type	Letter convention	Picture
2	M483A1	25A-[XX]	
4	105 Heat	25B-[XX]	
3	M243	25C-[XX]	
4	M374	25D-[XX]	
4	M720	25E-[XX]	
3	M74	25F-[XX]	
0	M385 Grenade	25G-[XX]	

Weather Conditions

- Weather on deploy was a challenge
- ERDC Team provided *almost* daily weather SITREPS to project stakeholders
  - Performers
  - Programs office
  - Technical Committee observers



SERDP ESTCP

FRF Weather Report

Valid 05 November 2025 – 1645 ET

Reporter: Spicer Bak

ERDC

Vertical lines are: **Deployment/Localization Days**

Performer Operation Days

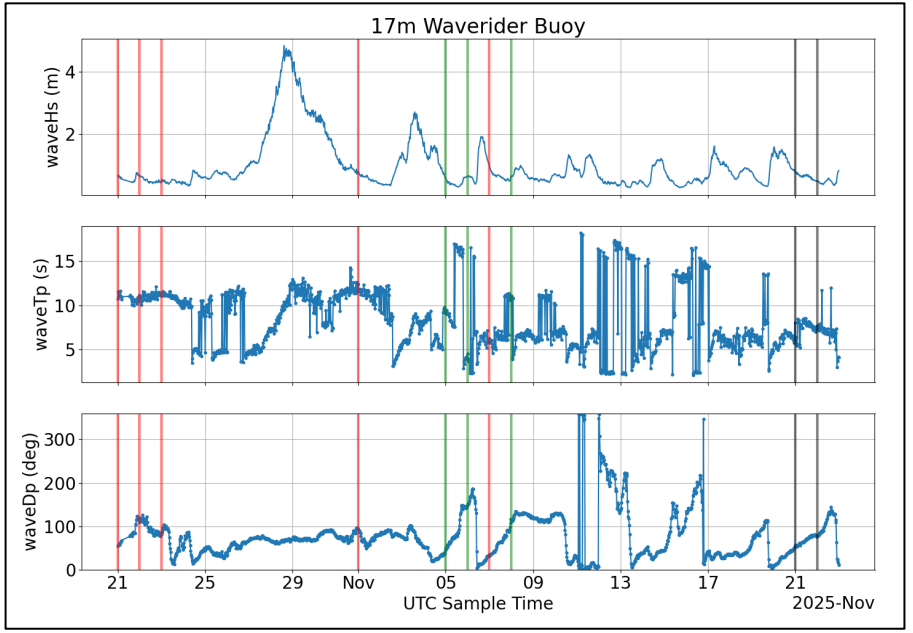
Recovery Days

ESTCP

Results to Date

- Deploy Days:
  - 21 October – 2
  - 22 October - 11
  - 23 October – 12

  - 1 November – 2
  - 7 November – 6 (resurvey)



Vertical lines are: **Deployment days**
Performer Operation Days
Recovery days

ESTCP

Background/Proposed Work
Pilot
Deploy
Host
Recover

Experiment

- Experimenter on site 4-9 November 2026
- In water 5,6,8 November

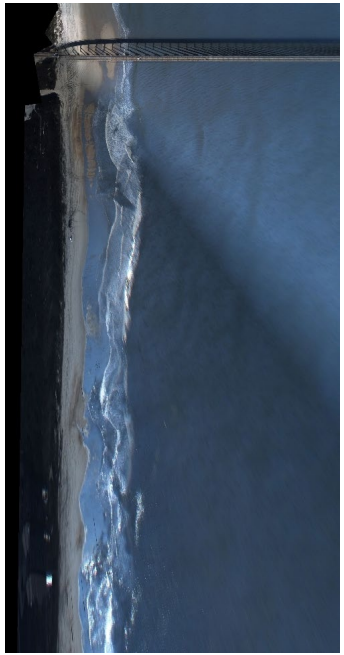
- Dry Beach Calibration line
  - **4 November**

Experiment

- Experimenter on site 4-9 November 2026
- In water **5**,6,8 November

- Weather Conditions
  - H_s – 1.67 ft
  - T_p – 16.7 s
  - D_p – 79 deg
  - U_{30} – 17.3 kts (SW)

Images from 5 – November (1600 UTC)

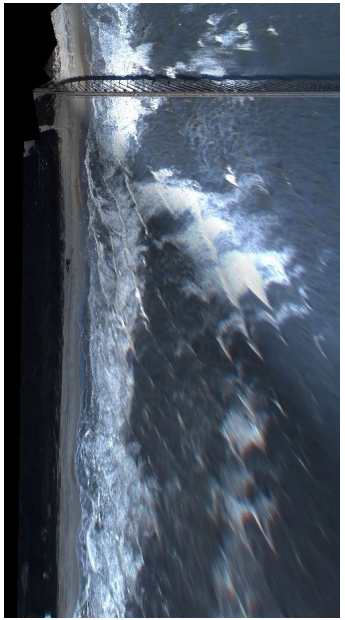


Experiment

- Experimenter on site 4-9 November 2026
- In water 5,**6**,8 November

- Weather Conditions
  - H_s – 6.2 ft
  - T_p – 6.67 s
  - D_p – 21 s
  - **U_{30} – 23 kts (N)**

Images from 6 – November (1600 UTC)



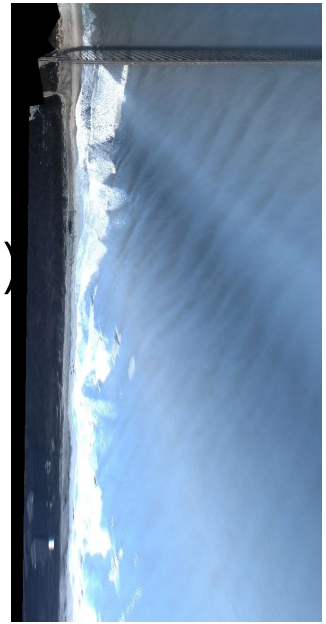
Note operations were sheltered by the FRF pier, not representative of buoy measurement

Experiment

- Experimenter on site 4-9 November 2026
- In water 5,6,**8** November

- Weather Conditions (1200 ET)
  - H_s – 2.4 ft
  - T_p – 6.7 s
  - D_p – 138 deg
  - **U_{30} – 6.6 kts (SW)**

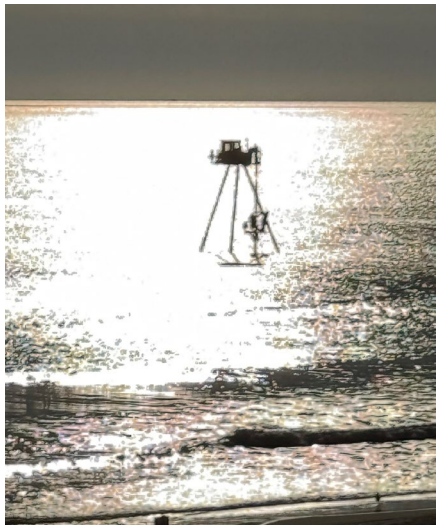
Images from 8 – November (1600 UTC)



Background/Proposed Work
Pilot
Deploy
Host
Recover

Recovery days

- Requirement change to Survey only sub-portion (8 locations) of deployed targets
- Team recovered
  - 21 November – 13 recovered 8 Surveyed
  - 22 November – 12 recovered 1 Surveyed
- NOTE: unable to recover 2 large TOIs (155mm)
- Data Delivered to IDA (12/15/2025)
- Data Adjudicated (1/12/2026)



Issues

- Government shutdown impacted purchasing and delivery of targets, project costs
  - Are we anticipating delivery of any more targets?
- Consistent high winds/waves delaying operations deployment
- Late season (shorter days, colder water) become impediments to efficiency
  - Increases costs to project

Next Steps

- Performer 2 scheduled for May 2026

Technology Transfer

- We intend to provide “how-to” on target localization as part of the final report
  - Statistical comparison between different methods of localization used
- Disseminated information via multiple published media/in-person venues including
  - ESTCP/SERDP Symposium, SAGEEP/EEGS
  - We will also incorporate this in training materials in the USACE FUDS training program.
- Beyond generating SERDP/ESTCP reports and presentations, the team will work with the other test sites within the SERDP/ESTCP programs to communicate successes and lessons learned to grow the knowledge base of test capabilities for SERDP/ESTCP and the larger DoD (e.g. USMC).

BACKUP MATERIAL

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

MR25-AZ-8606 Establishment of a Surfzone and Very Shallow Water Munitions Response Test Range

Performers: US Army Engineer Research and Development Center

Technology Focus

- *Establishment of a precise an safe demonstration site*

Demonstration Site

- *The Field Research Facility in Duck North Carolina*

Demonstration Objectives

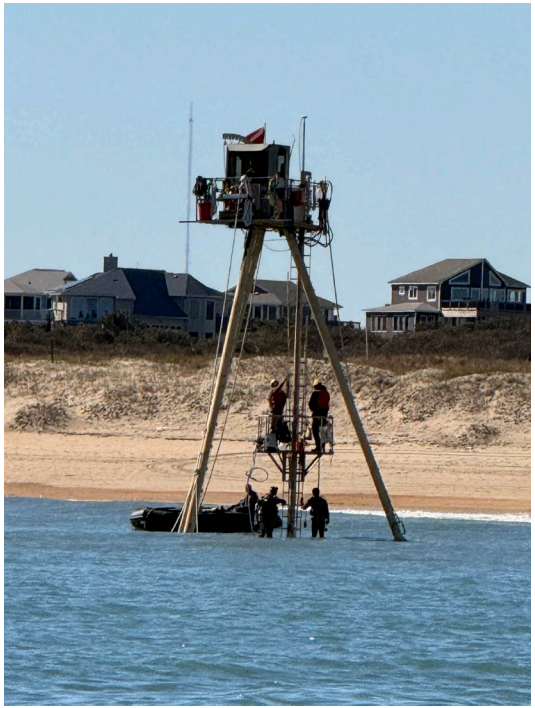
- *Deploy and recover targets with high accuracy. Provide safe experimentation environment*

Project Progress and Results

- *First deployment successful. Preparing for second performer.*

Implementation Status

- *Coordination with second performer just beginning.*



NOTE: This slide may used by the Program Office in future presentations to provide a brief overview of the project.

Plain Language Summary

- Testing Amphibious platforms safely is a challenging proposition with high hydrodynamic loading an TOI Mobility
- The FRF has provided a safe place to push boundaries and test safely while providing highly controlled TOI accuracy and uncertainty

Impact to DoD Mission

- Testing Amphibious platforms safely is a challenging proposition with high hydrodynamic loading an TOI Mobility
- The FRF has provided a safe place to push boundaries and test safely while providing highly controlled TOI accuracy and uncertainty
- High Priority Performer was able to successfully demonstrate technology that could be significant increase in technology capability for UXO Detection Classification and Localization (DCL)
- [see subsequent slides for imagery]

Expected DoD Benefit

- The DoD and SERDP-ESTCP programs benefit from a rapid test and refine cycle in technology development.
- Continual feedback during the technology development cycle allows more subtle course corrections and not large redirections, which can be a resource drain.
- most learning happens through failure, and being able to do so in a low-risk environment provides opportunities for rapid development without significant risk in cost or schedule, ensuring peak technology delivery.
- The robust background measurements also provide unprecedented knowledge of environmental factors in which these systems are being tested in, allowing for confident employment in similar environmental conditions at other locations.

Publications

- None

Literature Cited

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

Additional Slide(s) for High-Quality Photos

Additional Slide(s) for High-Quality Photos

Additional Slide(s) for High-Quality Photos

Additional Slide(s) for High-Quality Photos

Acronym List