Vibration-Induced Precision Emplacement Routine (VIPER): A rapid deployment system for buried and proud seed items at shallow underwater demonstration sites

MR23-7687

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US Naval Research Laboratory

In Progress Review Meeting

August 14, 2025

Project Team

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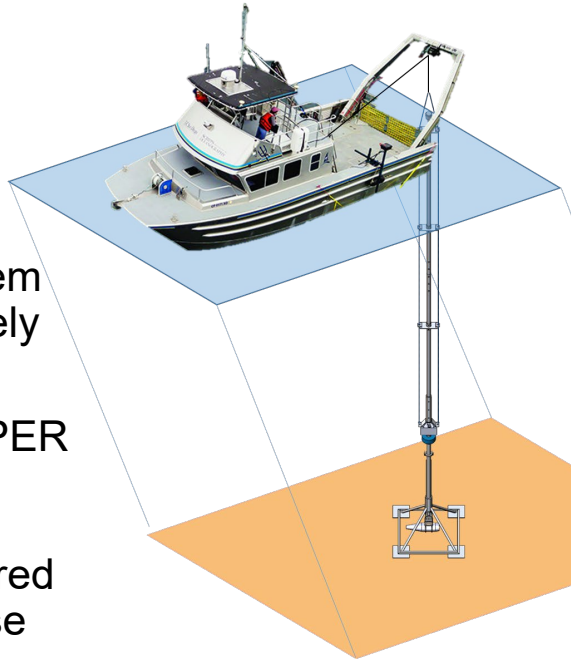
Additional Team Members: Amanda Ceroli & Claire Picou, *US Naval Research Laboratory*

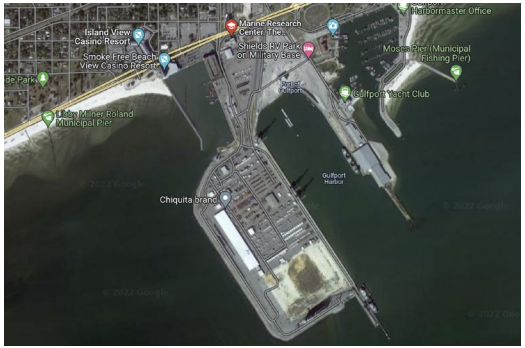
Bottom Line Up Front

- VIPER is a rapid deployment system for buried and proud seed items at shallow underwater demonstration or MRS sites. The system is designed to record RTK GPS position, orientation, and depth of each seed item, with the ability to predetermine seed position, orientation, tilt, and depth prior to deployment. The system will be deployable from most vessels of opportunity and will not rely upon SCUBA operations.
- The VIPER team has completed design and fabrication of the VIPER assembly for laboratory testing. Initial testing of the system in our laboratory has shown that the system will bury the seed items. Further testing and refinement of the release mechanism is required to ensure the jaws are able to fully open in the sediment to release the seed.



Site Description

- US Naval Research Laboratory, Stennis Space Center, MS
  - Laboratory testing is being performed in our hi-bay facility.
  - Some of the resources available are an indoor test pool, overhead crane, machine shop
- University of Southern Mississippi Test Area (Gulfport, MS)
  - Discussions have been initiated with personnel at the USM to conduct engineering test off *R/V Point Sur*.



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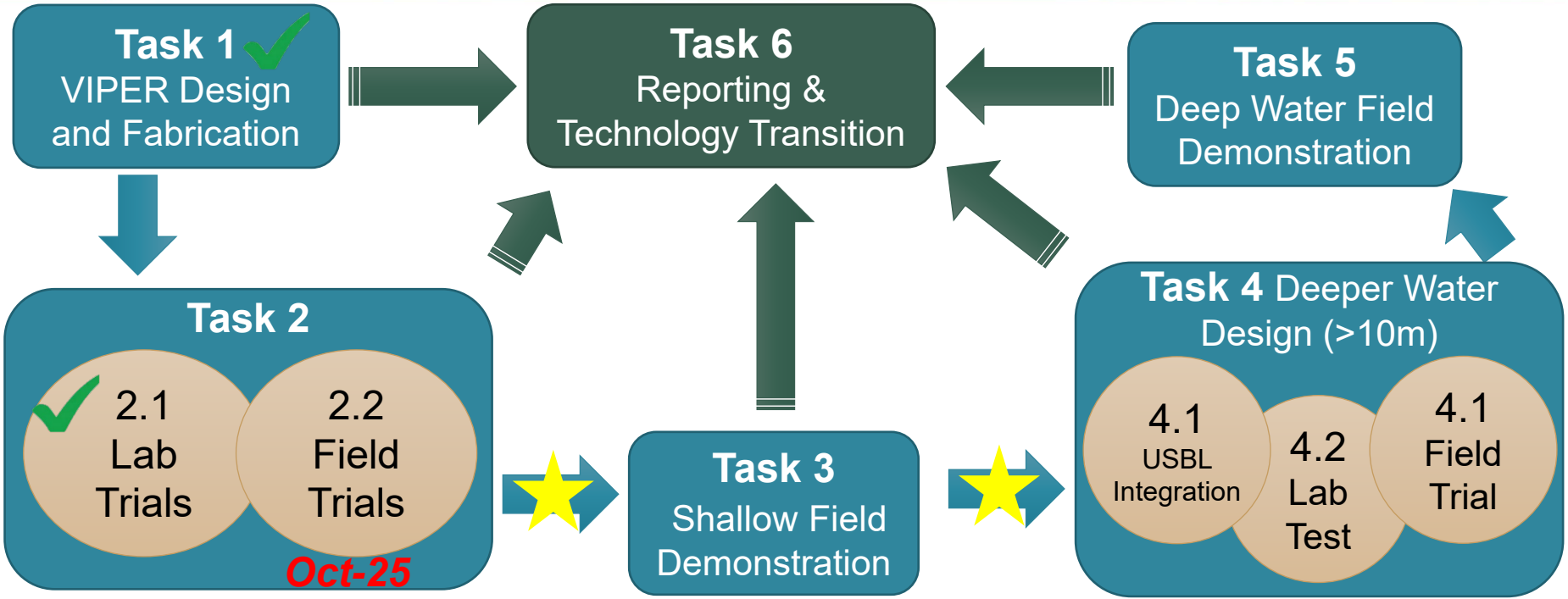
Technical Approach Overview



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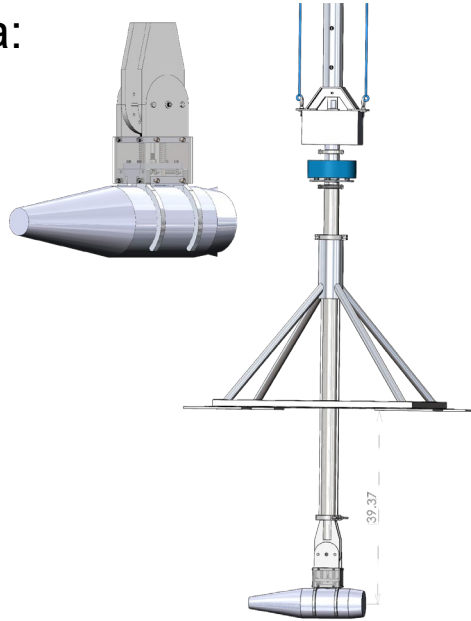
Technical Approach and Test Design

- The VIPER system is designed to meet the following criteria:
  - Positional accuracy within 1 m radius
  - Accurate seed burial depth
  - Accurate seed orientation and tilt
  - Burial depths up to 2 m below seabed
  - Accommodate a range of seed items (including, but not limited to sizes from 40mm up to 8” ISO)



Conceptual Design and Fabrication (Task 1)

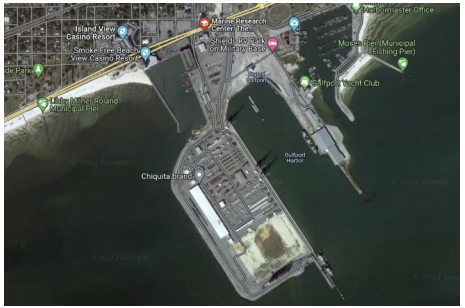
- Design for the VIPER frame and fabrication have been completed and a version of the VIPER system is currently in laboratory testing.
  - Equipment has been purchased and received
  - Custom frame designed and machined
  - Assembly of laboratory test instrument (lander frame not yet attached for small scale testing)

Technical Approach and Test Design

- **Laboratory Testing at NRL (Task 2.1)** ✓
  - Selected UXO will be implanted with VIPER
  - Seeds will be excavated by hand to verify orientation and depth of burial
  - Document any evidence of surface disturbance
  - Performance Objectives:
    - >100% burial below seafloor of seed items
    - Orientation and tilt of buried seeds reported by VIPER with <10% error
    - Depth of seed burial to within 10cm (measured from bottom of seed)
  - Next Steps
    - Field Test

Technical Approach and Test Design

- **Engineering Field Trials (Task 2.2)**
  - Selected UXO or surrogates will be implanted with VIPER in controlled field sites.
  - Field Site Selection
    - USM Test Area using *R/V Point Sur*
  - Performance Metrics: (includes metrics from Task 2.1)
    - Average error/uncertainty in GNSS position in meters to position reported by VIPER < 1m
    - Burial of seeds in sandy sediments > 100% burial below seafloor
  - Burial metrics will be measured to confirm VIPER reported values for penetration, orientation and depth of burial.
  - Seeds will be excavated and positions recorded by RTK GPS
  - *A **Go-No Go** decision will be rendered based on system meeting performance metrics in Field Trial*



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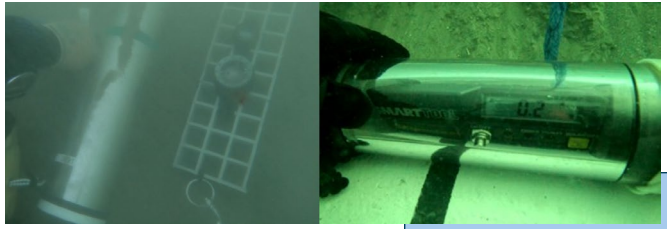
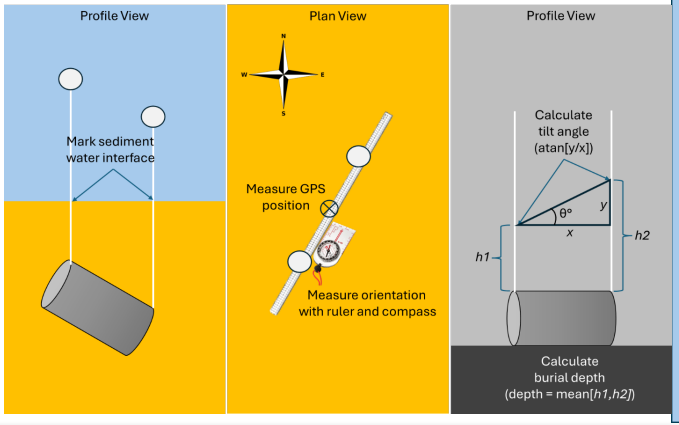
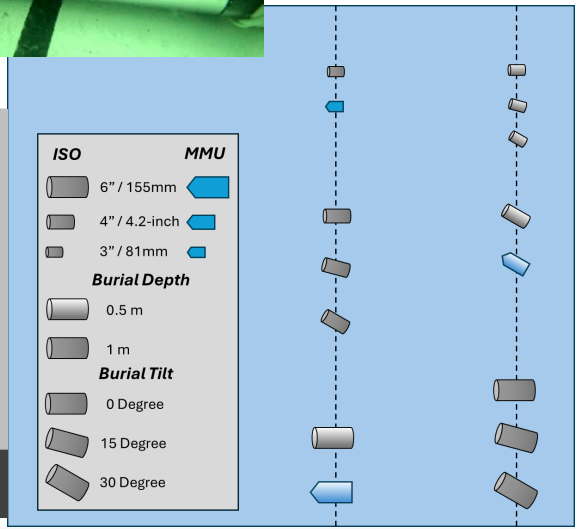
Technical Approach and Test Design

- **Field Trial (Task 2.2) - continued**
  - October 2025 (pending)
  - 5-8m water depth
  - Deploy seeds, verify with NAVO divers via two-line method and excavation
  - 15 total seeds
    - 12 ISO
    - 3 MMU
    - 3 sizes (81mm, 4.2inch, 155mm)
  - Test performance for:
    - Burial depths (0.5 m and 1 m)
    - MMU vs ISO
    - Tilt angle (0°,15°, and 30°)
    - Multiple sizes







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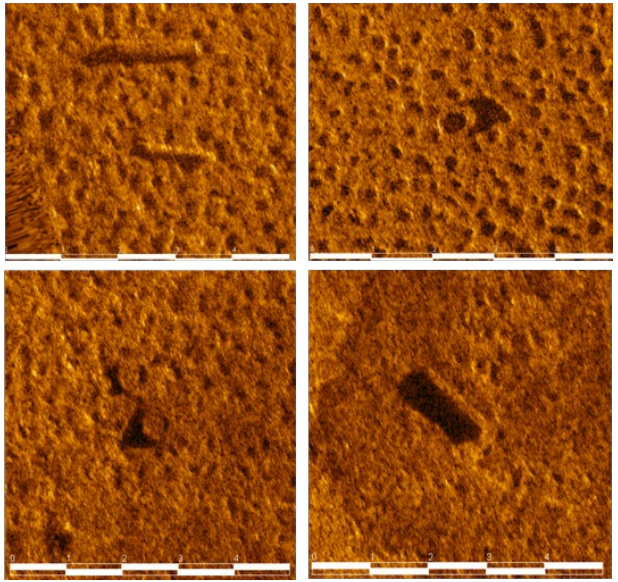
Technical Approach and Test Design

- **Field Demonstration (Task 3)**
  - Location TBD
  - Nearshore, shallow water < 10 m), sandy, dynamic environment
  - Additional performance metrics to those tested in Task 2, including rate of burial
  - Seeds will be deployed with lines attached to each end. Divers will be used to validate burial, orientation, and depth of burial.
  - Seeds will be excavated and burial depth and orientation recorded by divers.
  - IVER3 will perform pre- and post-deployment surveys with both sidescan and magnetometer to avoid existing seafloor and buried clutter and to detect seafloor scaring.



Technical Approach and Test Design

- **Deeper Water (> 10 m) Design and Configuration (Task 4)**
  - Task 4.1 – USBL System Integration
    - Addition of an iXblue GAPS M7 USBL system to the VIPER surface frame or pole mount to deployment vessel
    - Addition of an iXblue Oceano MT912S/R transponder to the VIPER benthic frame
  - Task 4.2 – Laboratory Testing
    - Determine any effects of vibracore high frequency vibration on USBL performance and mitigate any issues.
  - Task 4.3 – Field Trial
    - Repeat the engineering tests of Task 2.2 to establish real-world positional accuracy of the USBL enabled system in varying environmental settings
- **Deeper Water (> 10 m) Demonstration (Task 5)**
  - Identify a site of up to 30 m water depth to test the VIPER-fish performance
  - A team will deploy the VIPER system from a vessel of opportunity and will place buried seed items in the seafloor.
  - A predetermined number of seed items will be deployed, each with a target position, depth, tilt, and orientation.

Technical Approach and Test Design

- **Deeper Water (> 10 m) Demonstration (Task 5 continued)**
  - Seed items will be deployed with lines attached to each end to aid divers in measurements and reacquisition and recovery of seed items.
  - SCUBA divers from will excavate and measure the position, depth, tilt, and orientation of the seed items using traditional methods
  - IVER3 will perform pre- and post-deployment surveys with both sidescan and magnetometer to avoid existing seafloor and buried clutter and to detect seafloor scaring.
  - Performance metrics will be the same as those for Task 3.
- **Reporting (Task 6)**
  - We will provide full reporting of the VIPER design, construction, evaluation, and summary of performance.
    - Laboratory Test Reporting (Go/No-Go Deliverable)
    - Demonstration Plan
    - Final Report

Performance Objectives (Task 2.1)

Performance Objective	Data Requirements	Success Criteria
Quantitative Performance Objectives		
Penetration of test seed(s)	Measured % burial of seed below sediment water interface	> 100% burial below sediment water interface
Orientation	Lab measured orientation and tilt of buried seeds compared to values reported by VIPER	< 30° error in orientation and 10° tilt
Depth of burial	Measured burial depth of seed in meters compared to values reported by VIPER	Depth uncertainty < 10 cm

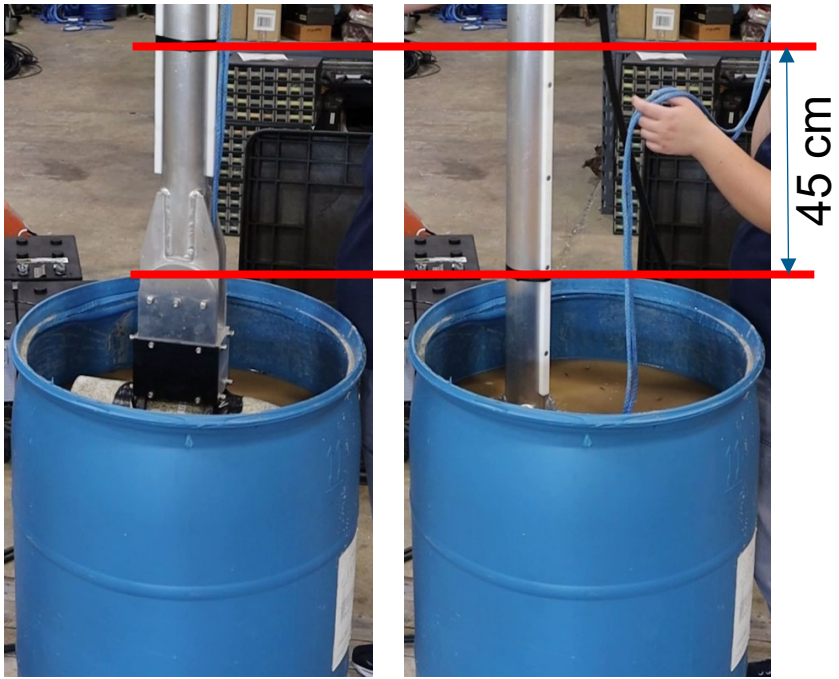
Performance Objectives (Task 2.2, 4.2)

Performance Objective	Data Requirements	Success Criteria
Quantitative Performance Objectives		
Performance metrics for Task 2.1 in addition to the following:		
Positioning	Average error / uncertainty in GNSS position in meters compared to values reported by VIPER	Seed position error < 1 m
Maximum Burial Depth	Maximum burial depth (dependent upon substrate*)	Up to 1 m burial in unconsolidated sands
Seed Size	Ability to bury all seeds within a prescribed range of seed size	100% burial of seeds ranging from 3” - 6” ISO

Performance Objectives (Task 3, 5)

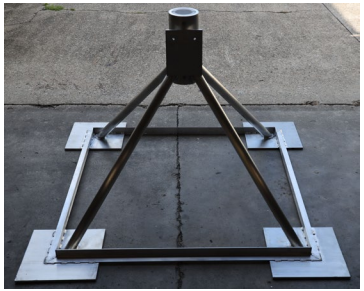
Performance Objective	Data Requirements	Success Criteria
Quantitative Performance Objectives		
Performance metrics for Task 2.1 and Task 2.2 in addition to the following:		
Maximum Burial Depth	Maximum burial depth (dependent on substrate)	>1m burial in unconsolidated sands
Seed Size	Ability to bury all seeds within a prescribed range of seed size	100% burial of seeds ranging from 2” to 6” ISO
Burial Rate	# seeds placed / hour	TBD based on Task 2 Results

Results to Date



- 1st laboratory test:
  - 45cm burial of 4.2in projectile
  - Burial to depth was approx. 30 seconds
  - Drum contained fine - very fine sediment
- Challenges to address:
  - Need to add adjustments to jaws to firmly grip seed
  - Need to add barrier to keep sand out of release mechanism.

Results to Date



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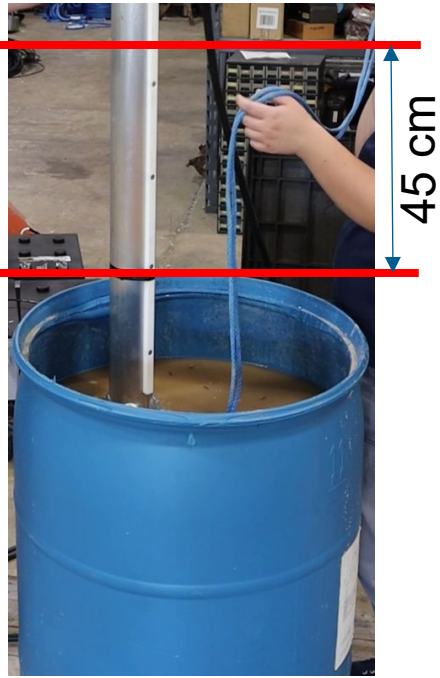
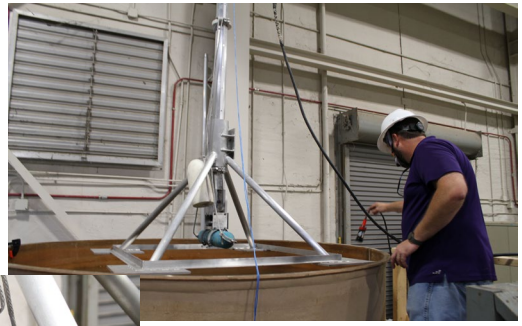


(e)

Results to Date

- Laboratory Tank Test
  - 1m x 1m x 0.6m container with sand
    - D50 = 0.51mm (coarse sand)
  - Trial 1 - 4.2" MMU
    - Run time 27 min – paused after no further observed movement

Metric	Target	Actual
Depth (cm)	60	34
Tilt Angle	0	0



Results to Date

- Laboratory Tank Test
  - 1m x 1m x 0.6m container with sand
    - D50 = 0.51mm (coarse sand)
  - Trial 1 - 4.2" ISO
    - Run time 14 min – paused after no further observed movement

Metric	Target	Actual
Depth (cm)	60	13
Tilt Angle	0	0

  - Complications – infilling of hollow ISO? Packed sand in tank from previous run?

Results to Date (Task 2.1)

Performance Objective	Data Requirements	Success Criteria	Results to Date
Quantitative Performance Objectives			
Penetration of test seed(s)	Measured % burial of seed below sediment water interface	> 100% burial below sediment water interface	Achieved > 100% burial on 3 tests
Orientation	Lab measured orientation and tilt of buried seeds compared to values reported by VIPER	< 30° error in orientation and 10° tilt	Tilt within expected range; orientation requires further testing
Depth of burial	Measured burial depth of seed in meters compared to values reported by VIPER	Depth uncertainty < 10 cm	Requires further testing to validate

Issues

- Planned for engineering test at FRF in Aug, but deploying VIPER off CRAB requires modifications to CRAB outside of scope / timeline of engineering test
- One of the original team members left NRL just before the project start, slowing the completion of the initial design.
- Acquisition of some materials delayed fabrication of the main frame tube and benthic lander frame.

Next Steps

- Continuing Laboratory Testing
- Engineering Design Test – Gulfport, MS (Oct 2025)
- Submit Report of Laboratory Trials and Engineering Test
  Dec. 15, 2025
- Plan a local test in muddy-sand environment
- Submit Demonstration Plan – Jan. 31, 2026

Technology Transfer

- The project will produce a fully deployable seed burial technology hosted by NRL and ready for immediate application at demonstration sites funded by ESTCP and MRS sites for sensor verification / validation.
- We will work closely with ESTCP and demonstration site managers to address needs and requirements expressed in the previous Underwater UXO Standardized Demonstration Sites (Test Beds) Workshop, as well as any additional requirements unique to the individual demonstration/live sites should they arise.
- This collaborative approach will yield a set of design standards and best practices, as well as lessons learned, to be reported and outlined in detail for use by demonstration/live sites.

BACKUP MATERIAL

MR23-7687: Vibration-Induced Precision Emplacement Routine (VIPER): A rapid deployment system for buried and proud seed items at shallow underwater demonstration sites

Performers: Edward Braithwaite, Dr. Carter DuVal, *US Naval Research Laboratory*

Technology Focus

- *Develop, test, and demonstrate a new method to efficiently and accurately deploy buried seed items using a custom release mechanism and a modified vibracore head.*

Demonstration Site

- *TBD – Candidates include USACE FRF Duck, NC; San Diego, CA*

Demonstration Objectives

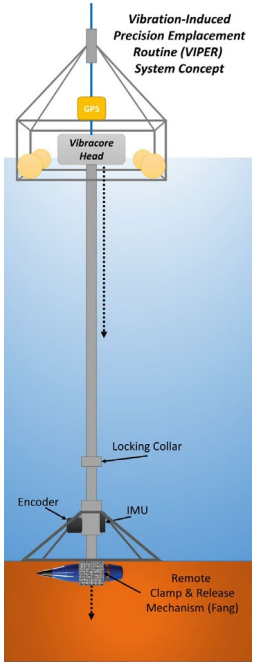
- *Bury a selection of seed items from 40mm to 8in diameter in both sandy and muddy sediments to a depth >1m with positional accuracy <1m, burial depth to <10cm uncertainty, and orientation and tilt with <10% error.*

Project Progress and Results

- *Initial laboratory tests resulted in 45cm burial of a 4.2in projectile.*

Implementation Status

- *The project will produce a fully deployable seed burial technology hosted by NRL and ready for immediate application at demonstration sites funded by ESTCP*
- *A deeper water version of the VIPER will be developed relying on USBL for underwater positioning. This version of the VIPER will have an anticipated operational depth of up to 30m for test beds such Sequim Bay, WA.*



ESTCP

Plain Language Summary

- ESTCP supports Demonstration sites for Munitions Response (MR) technologies to detect, classify, or remediate munitions found at underwater sites (FY23 ESTCP Munitions Response Topic D2).
- Accurately deploying a large number of seeds at test beds remains costly and time consuming, and typically relies on traditional methods such as SCUBA
- Develop, test, and demonstrate a new method to efficiently and accurately deploy buried seed items
  - Use COTS vibracore to bury seed items
  - Use RTK GPS coupled with an IMU for accurate position and orientation
  - Mechanical stop collar and encoder to verify depth of burial
  - Deployable from vessel of opportunity
  - Version 1, Operate in shallow water up to 10-m depth. Version 2, Operate to 30-m water depths with USBL

Technical Approach and Test Design

- **Field Demonstration (Task 3 continued)**
  - Field Demonstration Performance Metrics:
    - <10% error in orientation and tilt values reported by VIPER compared to diver report
    - <10cm depth uncertainty in values reported by VIPER compared to diver report
    - Average error/uncertainty in GNSS position in meters to position reported by VIPER < 1m
    - Burial of seeds in both sandy and muddy sediments > 100% burial below seafloor
    - For unconsolidated sands, >1m burial depth
    - Ability to achieve 100% burial for all seed items selected in a range of 2” to 8” ISO.
    - Burial Rate, # seeds placed per hour TBD based on Task 2 results.
  - *Comparison of position, depth, tilt and orientation of VIPER system to data verified by divers*
  - Additional metrics reported may include:
    - Personnel requirements, Operational costs, Vessel requirements

Impact to DoD Mission

- The Program Office wants to convey the significance of your research to DoD leadership, Congress, and the broader community.
  - Started conversations about placing seed items at live sites for demonstrations.
  - Initial testing showed successful burial of an inert 4.2in projectile

Publications

- Patent Application
  - Braithwaite, E. F., Duval, C., "System and Method for Vibration-Induced Precision Emplacement Routine," Provisional Patent Navy Case 211222-US1, 2022
- Poster
  - Braithwaite, Edward F. III, DuVal, C., “Vibration-Induced Precision Emplacement Routine (VIPER): A rapid deployment system for buried and proud seed items at shallow underwater demonstration sites”, DOD Energy & Environment Innovation Symposium, 29 Nov 2023, Arlington, VA.

Literature Cited

- SERDP-ESTCP Final Report, Underwater UXO Standardized Demonstration Sites (Test Beds) Workshop Report, SERDP/ESTCP 2018 Symposium, M. Richardson (ed.), 2018.

Additional Slide(s) for High-Quality Photos

Acronym List

COTS: Commercial Off-the-Shelf
DoD: Department of Defense
ESTCP: Environmental Security Technology Certification Program
GNSS: Global Navigation Satellite Systems
GPS: Global Positioning System
IMU: Inertial Motion Unit
NRL: Naval Research Laboratory
RTK: Real-time Kinematic
SCUBA: Self-Contained Underwater Breathing Apparatus
SERDP: Strategic Environmental Research and Development Program
US: United States
UXO: UneXploded Ordnance
VIPER: Vibration-Induced Precise Emplacement Routine

Results to Date

Performance Objective	Data Requirements	Success Criteria	Performance Results
Quantitative Performance Objectives			
Performance metrics for Task 2.1 and Task 2.2 in addition to the following:			
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