UXO Detection in Tropical Environments and Volcanic Iron-Rich Soils

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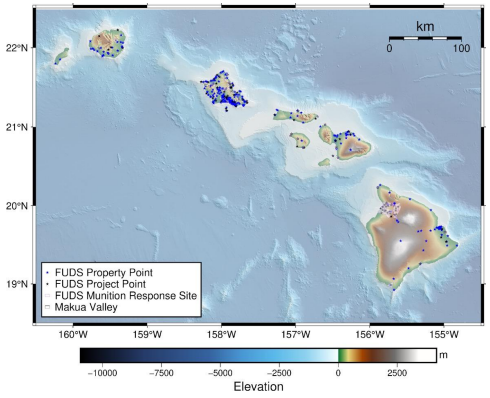
Why are there UXO in Hawaii?

- Since WWII, many of the Hawaiian islands have been used as targets for bombing runs and sites for munition disposal.
- Over 100 former and active military training sites scatter the Hawaiian islands, leaving dangerous unexploded weapons of war behind
- Multiple attempts at UXO cleanup have yielded varying results, and have not fully remediated sites on nearly **200,000 acres**

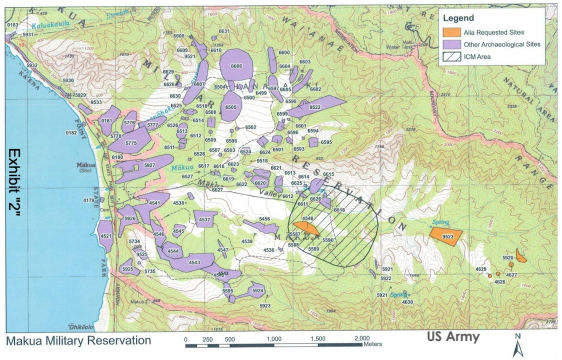


Challenges of finding UXO in Hawaii

- Iron-rich volcanic soils with strong magnetic properties
- Geospatial variability in soil composition
- Rugged terrain ranging from sandy beaches to jagged lava fields and steep mountainous forests
- Unique GPS challenges due to limited permanent base station infrastructure, and obstructed satellite line-of-site caused by steep mountain ranges and the region's remote Pacific isolation

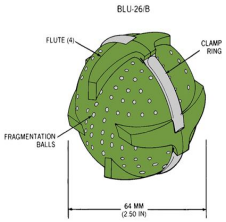
Tropical Paradise with a Dangerous Secret

Our study focuses on two geologically distinct sites on two islands: Mākua on Oahu, and Waikoloa on Hawaii Island



Mākua Valley is characterized by densely forested jungle, uneven terrain, and moist red volcanic clay. It is also home to a high concentration of archaeological sites of great cultural significance to the Hawaiian people. The presence of ***Improved Conventional Munitions*** (ICMs) in the area has hindered UXO remediation efforts, complicating restoration and access.

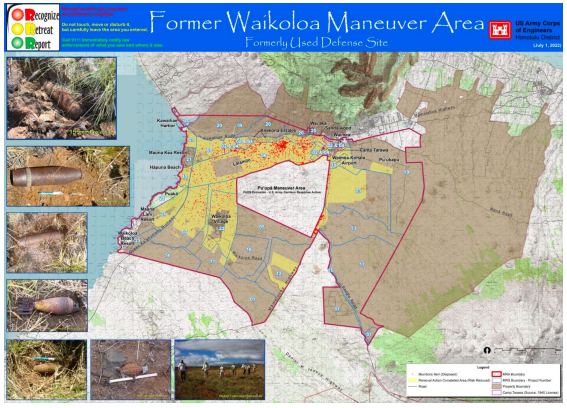
Jungle environment, Mākua



ICM dimensional schematic

Photo of ICM in-situ, Mākua Valley courtesy of US Army

Waikoloa, by contrast, features expansive, rugged lava flows rich in iron. The terrain is harsh and difficult to navigate, rendering large vehicle-towed advanced geophysical classification (AGC) systems ineffective or entirely unusable in many zones.



US Army Formerly Used Defense Sites (FUDS)

Graduate student taking soil sample, Waikoloa

Lava flow near Waikoloa Village, a resort area within the WMA

Methodology, Progress and Plans

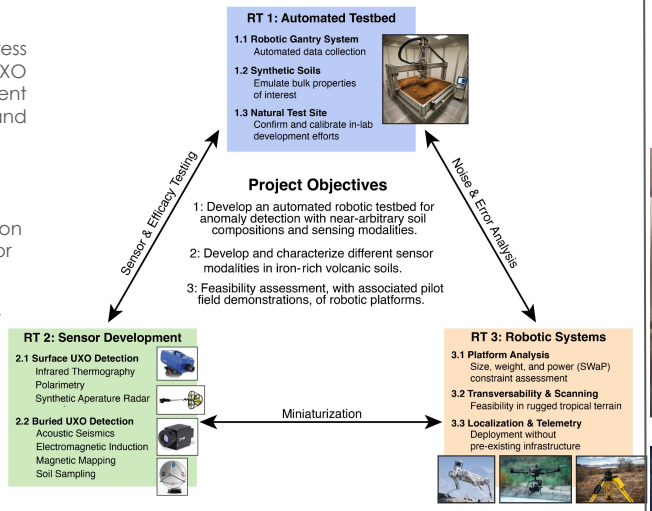
Project Outline

Our new project aims to address **Hawaii-specific challenges** related to UXO remediation using novel instrument developments as well as simulation and data processing workflows.

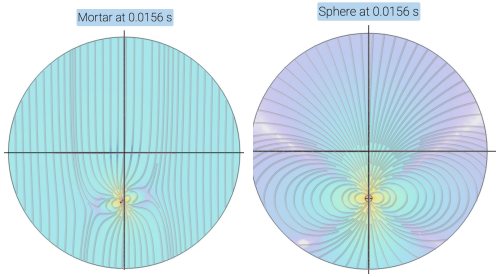
UH Mānoa plans to focus on 3 specific thrusts:

- Sensor development and fusion
- Automated testbed for sensor testing
- Robotic system design for automated detection, target interrogation and retrieval

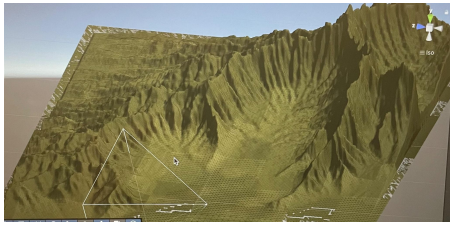
The integration of advanced multiphysics simulation tools enables detailed modeling of UXO behavior in diverse conditions. These simulations support the evaluation of signal response characteristics, and environmental interactions,providing guidance for our system design and expectations



Each UXO site in Hawaii is **geophysically unique**, requiring a tailored sensor development, deployment, processing, and workflow solution for each location



COMSOL physics simulation of time domain magnetic flux response of a metal sphere, mortar



Topographical visualization of Mākua, courtesy of Purple Mai'a

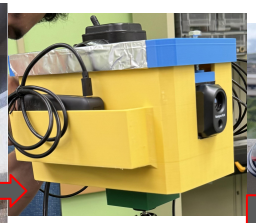
Partnering with local stakeholders—including community members, cultural practitioners, farmers, non-profits, industry experts, and the U.S. military—to co-develop responsible and effective UXO detection strategies rooted in place-based knowledge, technological innovation, and shared stewardship

Work in Progress

UROP (Undergraduate Research Opportunities Program) Project

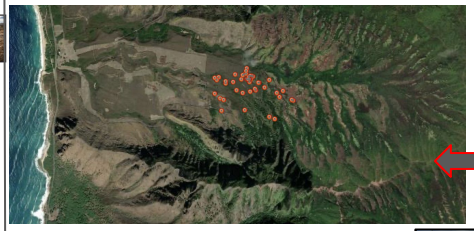
- Goal to autonomously detect and geolocate surface targets using drone mounted IR
- Experimenting with detection using computer vision, YOLO CNN [1] and Physics Informed Neural Network (PINN) [2]
- Potential integration with ground based robotics for inspection and collection of targets
- Establishing workflow for other drone mounted sensors and eventual sensor fusion

UXO Phantom with scrap metal

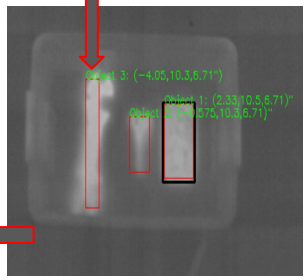


IR Camera

RTK GPS



GIS Layering for data visualization of targets, Mākua



Geolocated IR Targets

The UH Drone Technologies (UHDT) undergraduate team is instrumental in the iterative design and fabrication of **custom UAV platforms**, integrating several modular sensor payloads and developing autonomous flight protocols to support advanced UXO detection in geophysically and logistically challenging environments.

UHDT UAV preparing for flight operations testing

[1] (Bajić, M., Jr.; Potoc˘nik, B. UAV Thermal Imaging for Unexploded Ordnance Detection by Using Deep Learning. *Remote Sens.* 2023,*15*,967. https://doi.org/10.3390/rs15040967)

[2] S. Zideh et al., "Physics-Informed Machine Learning for Data Anomaly Detection, Classification, Localization, and Mitigation: A Review," J. Mach. Learn.