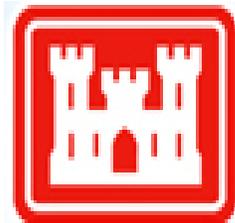


# UAS mounted EMI Sensor for UXO detection and classification

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THAYER SCHOOL OF  
ENGINEERING  
AT DARTMOUTH



**Subsurface Sensing**  
Technologies and  
Consulting

ჩამორული  
სხეულების სენსორების  
ტექნოლოგიები და კონსულტაცია

# Problem Statement

- Airfields are most immediate and lucrative targets for an adversary
- Destroying the runways basically means destroying the entire air operations



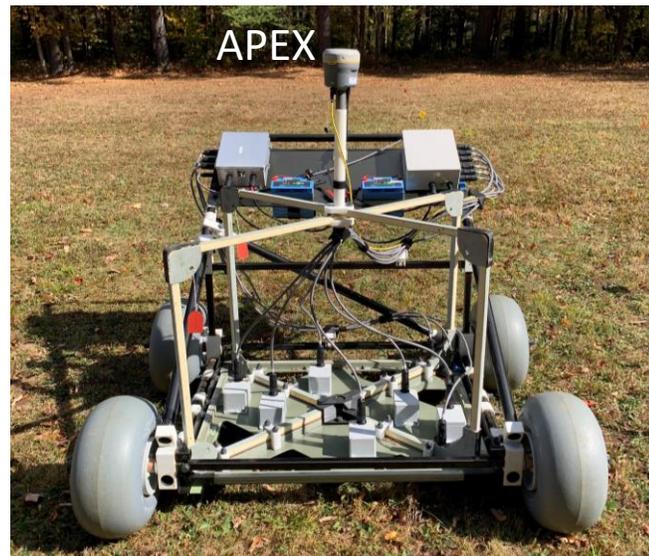
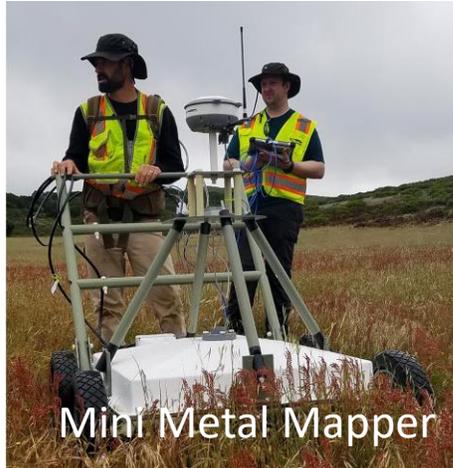
Subsurface UXO



Rapid Airfield Damage Assessment System (RADAS)

**Goal:** To develop, build and mount Ultralightweight system for rapid airfield damage assessment.

# Current Advanced EMI sensors



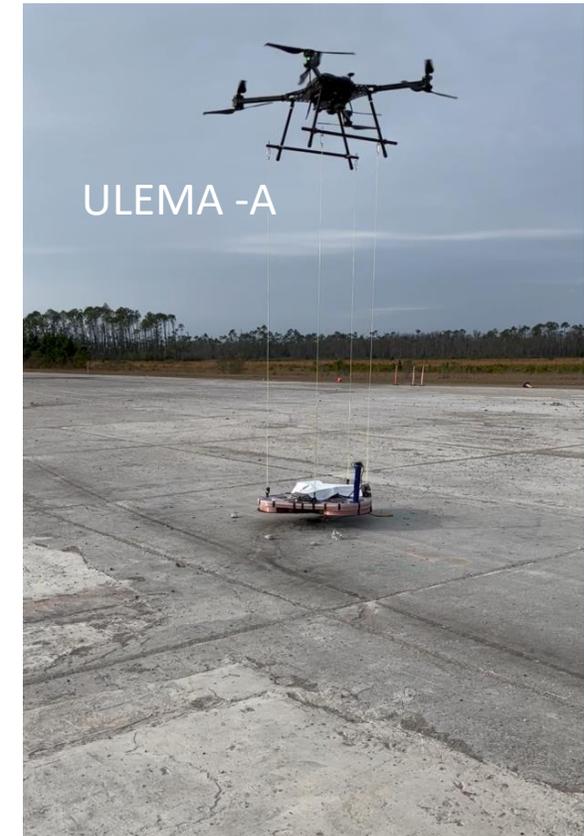
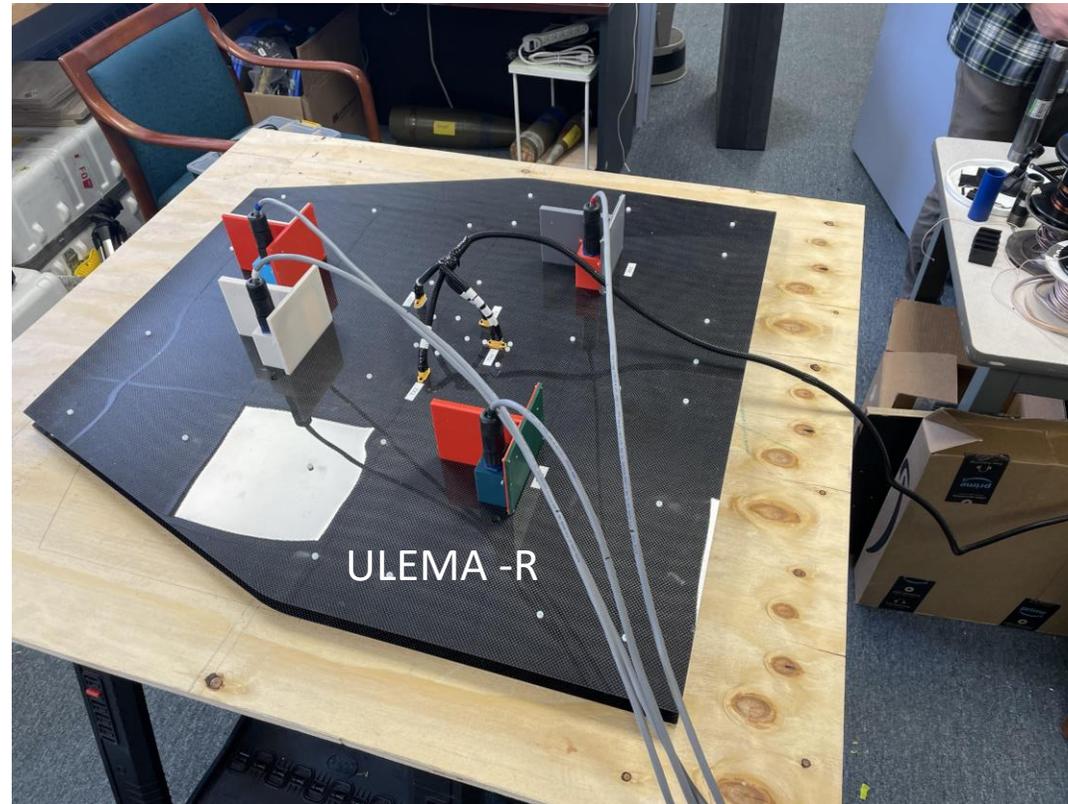
# ULEMA: Ultra-Light ElectroMagnetic Array

## Custom Rx designed

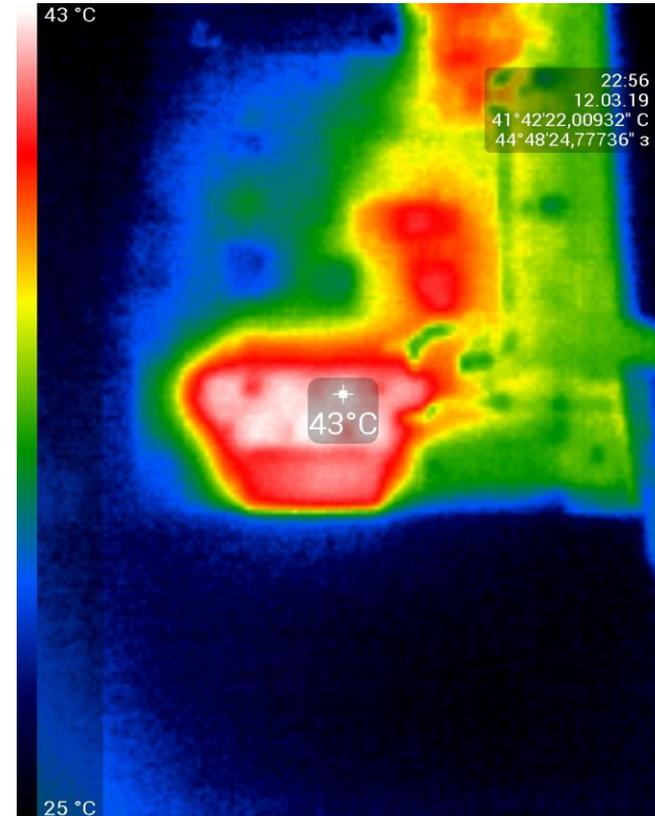
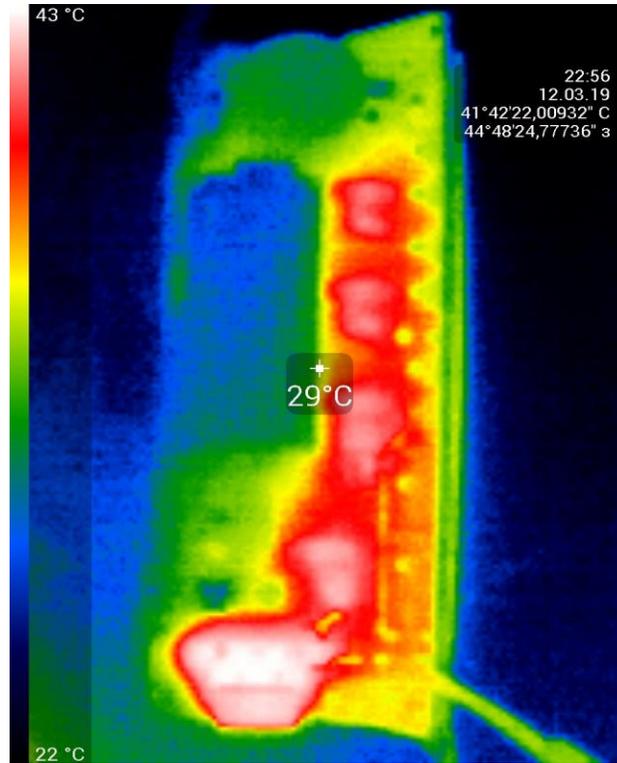
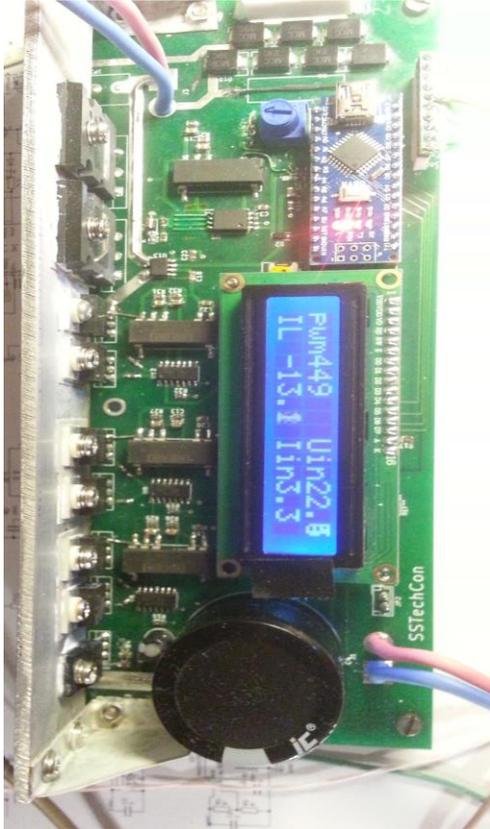
- Small and lightweight
- 10 layer PCB
- 10 turns on each layer, 10cm square
- Center tap for instrumentation amp
- 3-channel Rx amplifier board Low noise preamp

## Data pathways and DAQ system

- Mini PC running Windows10
- Multi channel DAG with 10MS/s
- Custom Tx PCBs

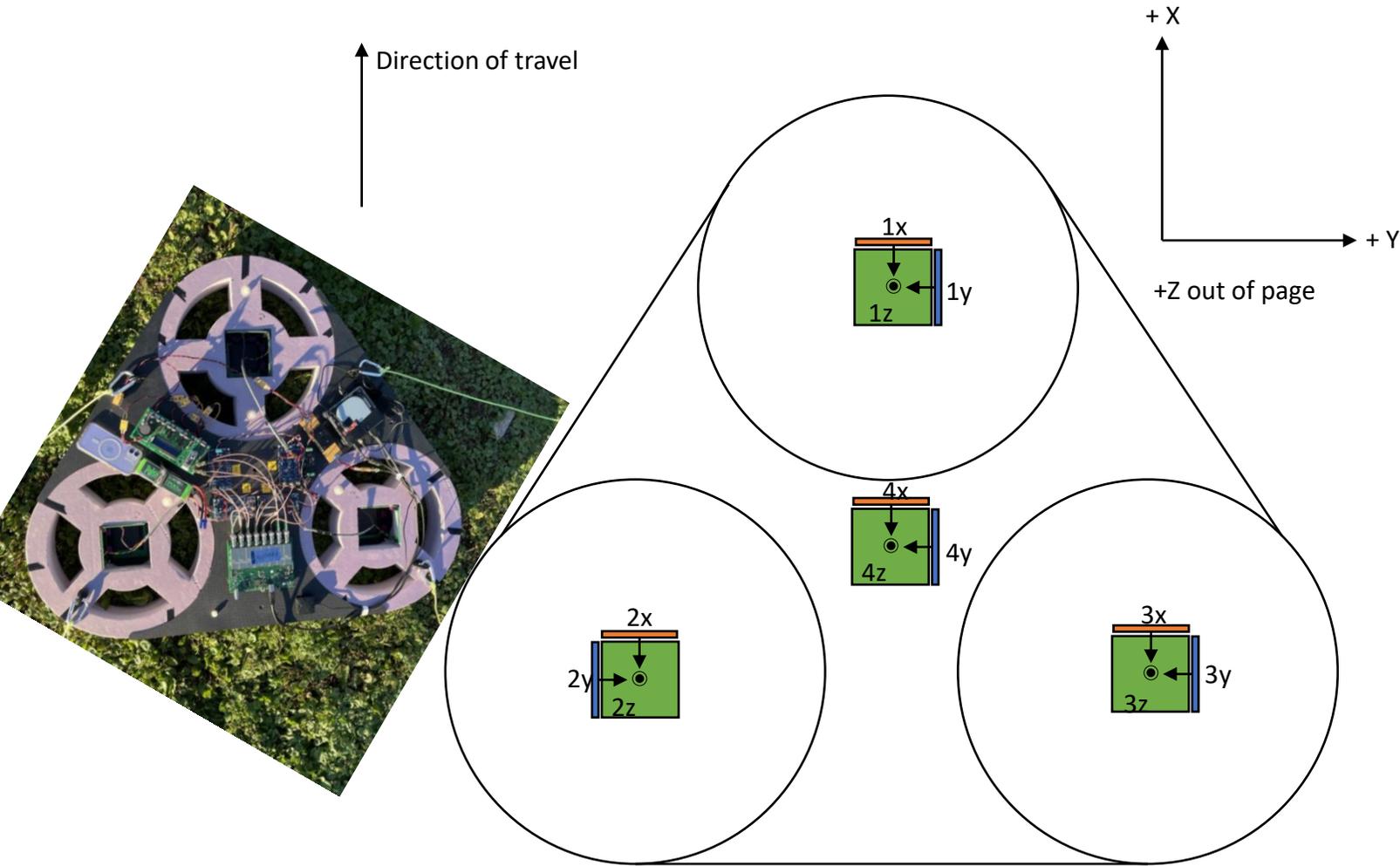


# System's Robustness



Temperature distribution map on the Tx board surface after 2 hours of continuously operating the system

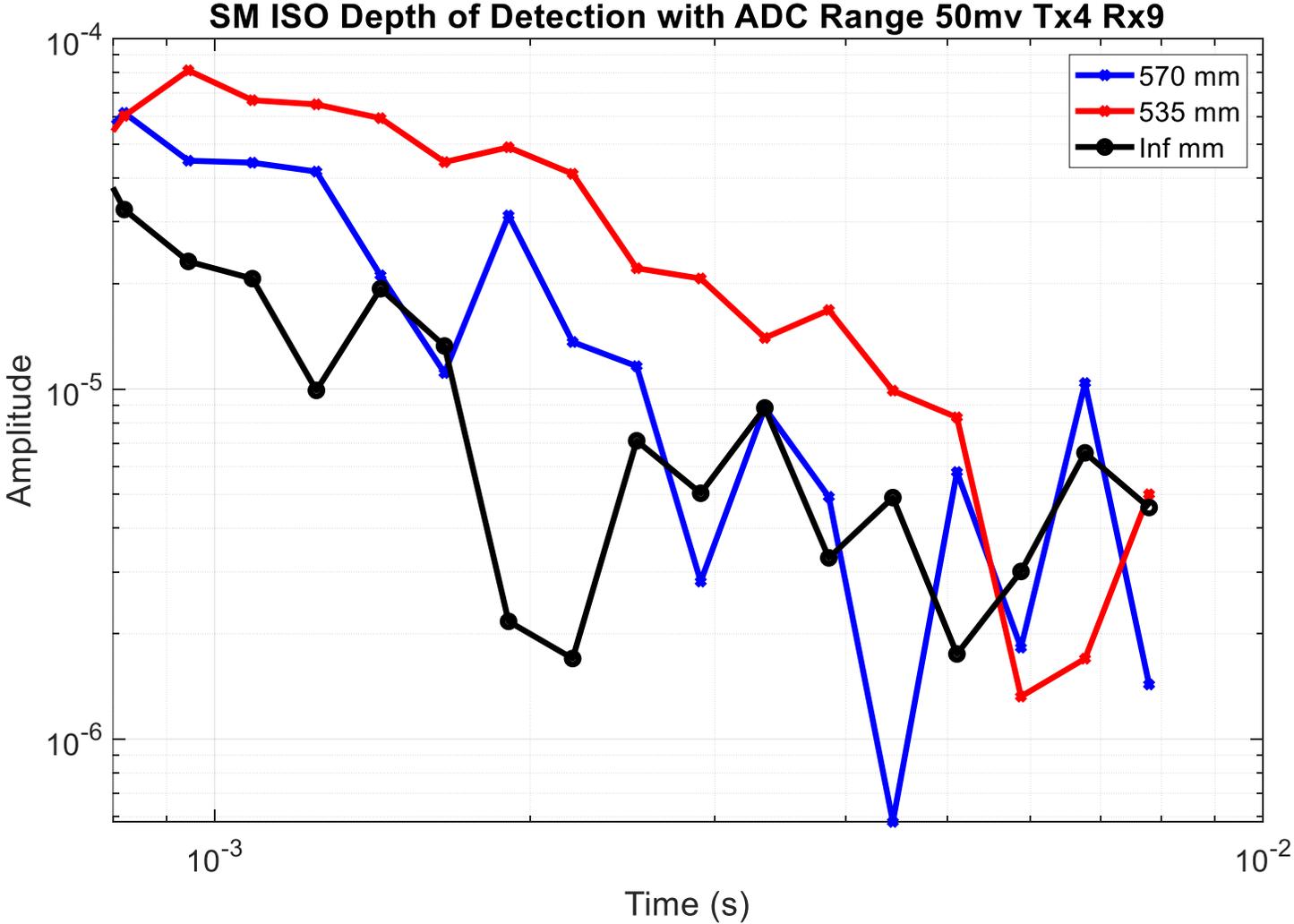
# ULEMA-A



- consists of three 45 cm diameter small and one large transmitter loops;
- weighs about 13.5 pounds.
- The three small Tx coils are designed to illuminate targets from different sides.
- Large Tx coil is used to enhance detection, location, and identification of deep targets.
- The Rxs collect target responses at a sample rate of 10 MHz.
- outputs the raw transient decay measurements grouped into 30 logarithmically spaced time gates whose center times range from 100  $\mu$ s to 8.3 ms

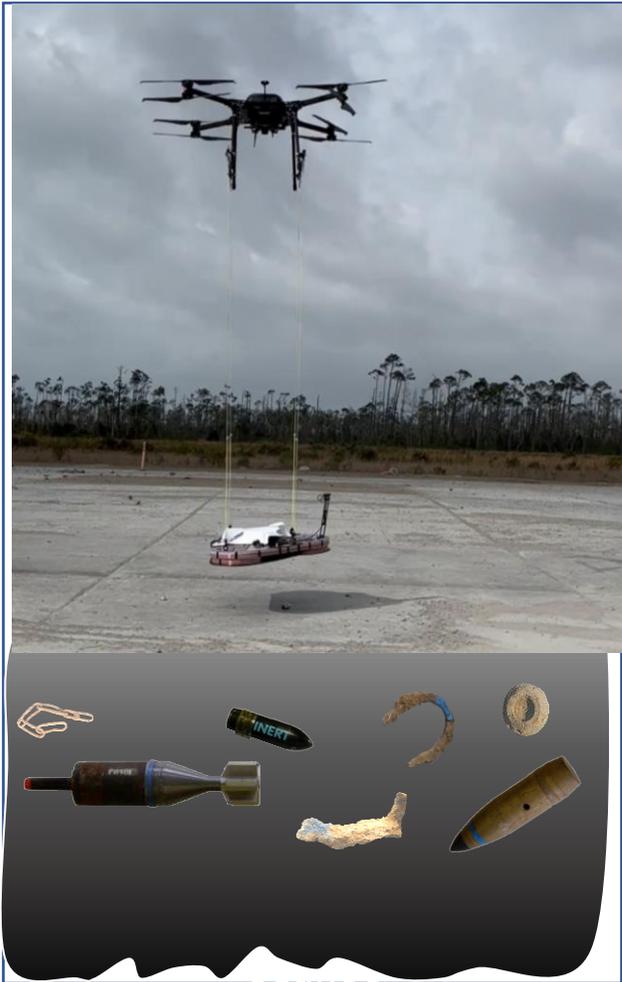
↑ Rx Normal Vector (Referenced to topside of PCB)

# Wide dynamic range

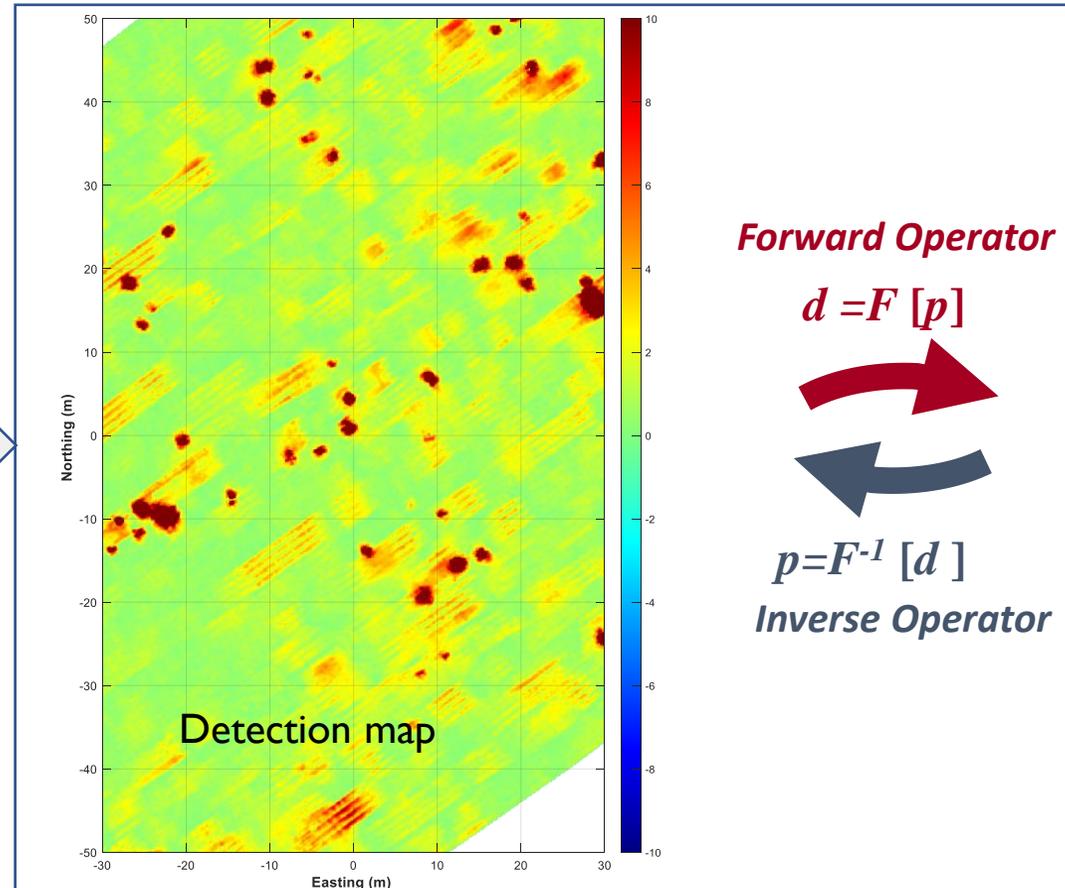


# UXO classification workflow

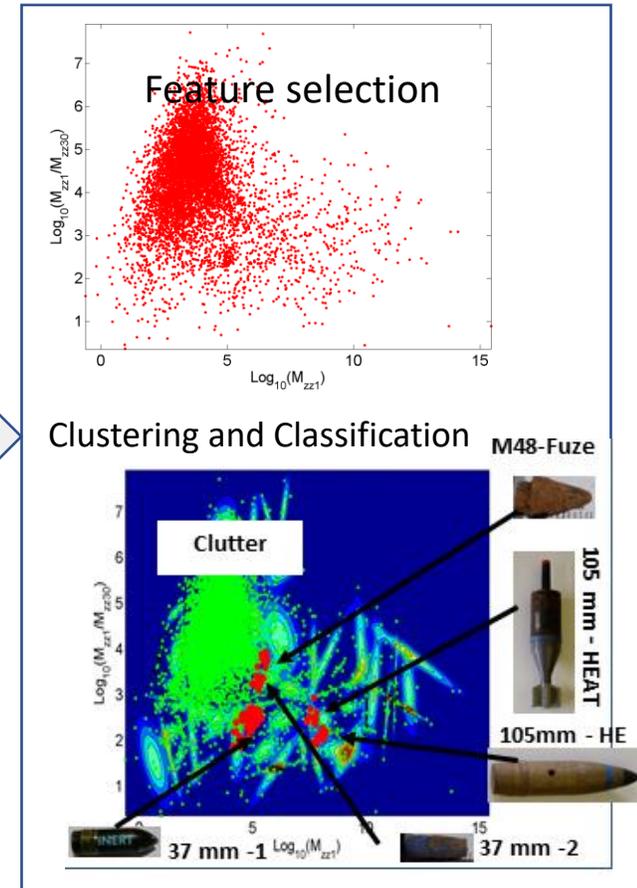
## 1. Data Acquisition



## 2. Data Inversion



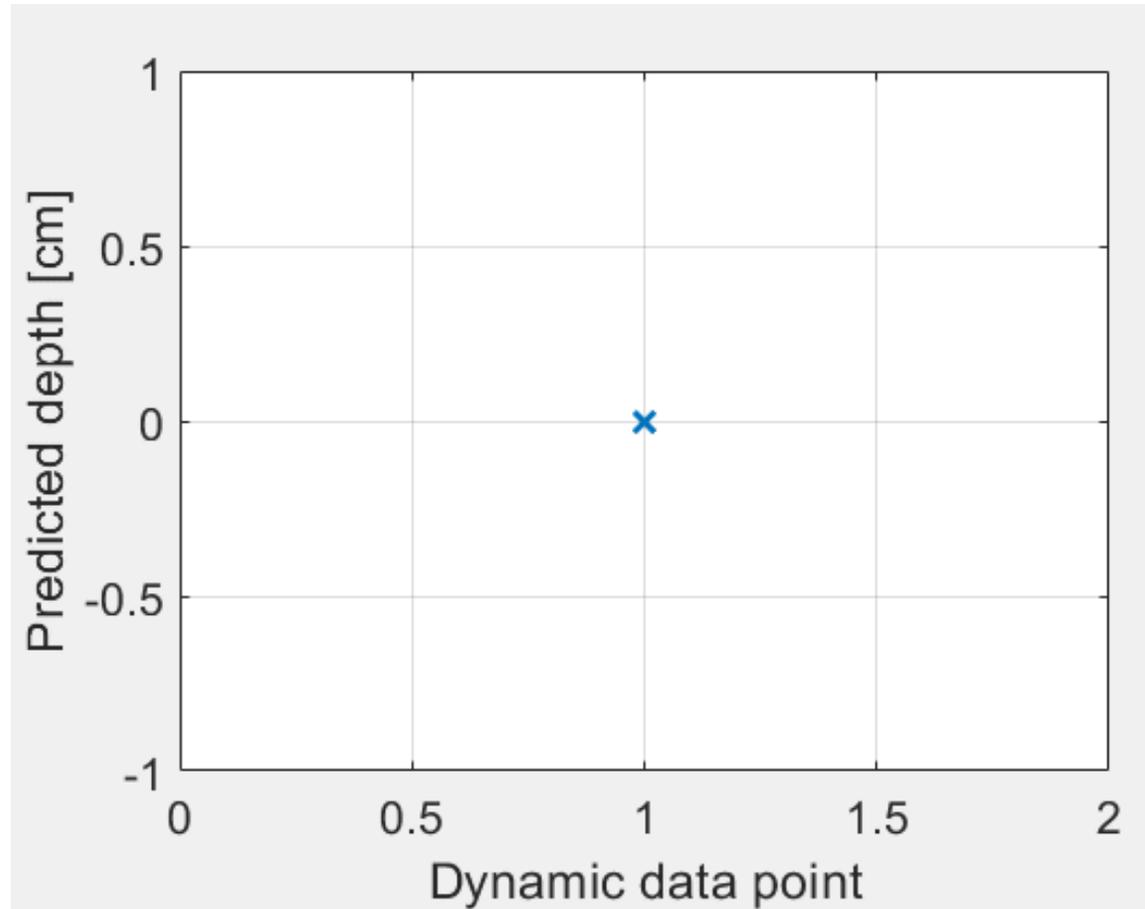
## 3. Decision



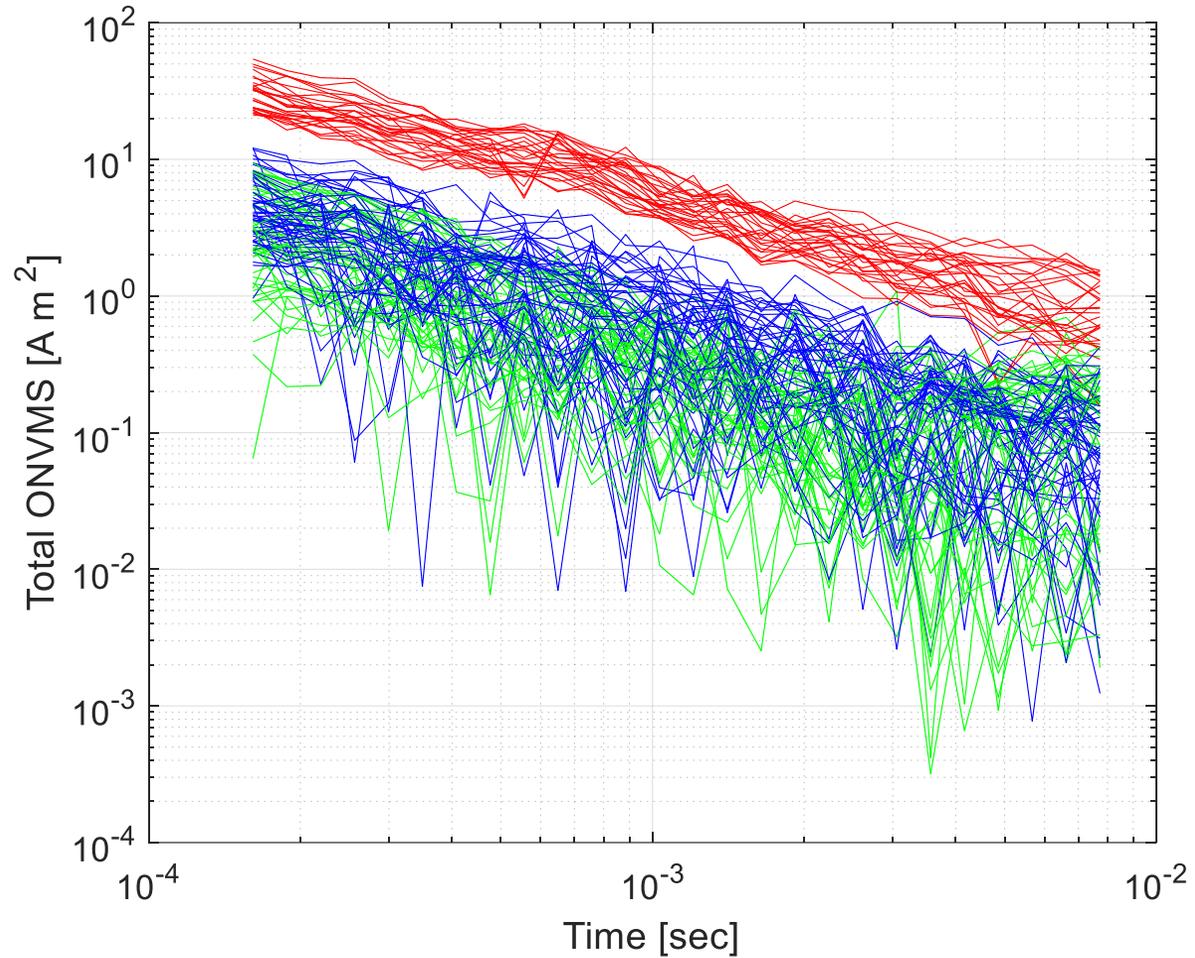
# UAS Data Collection



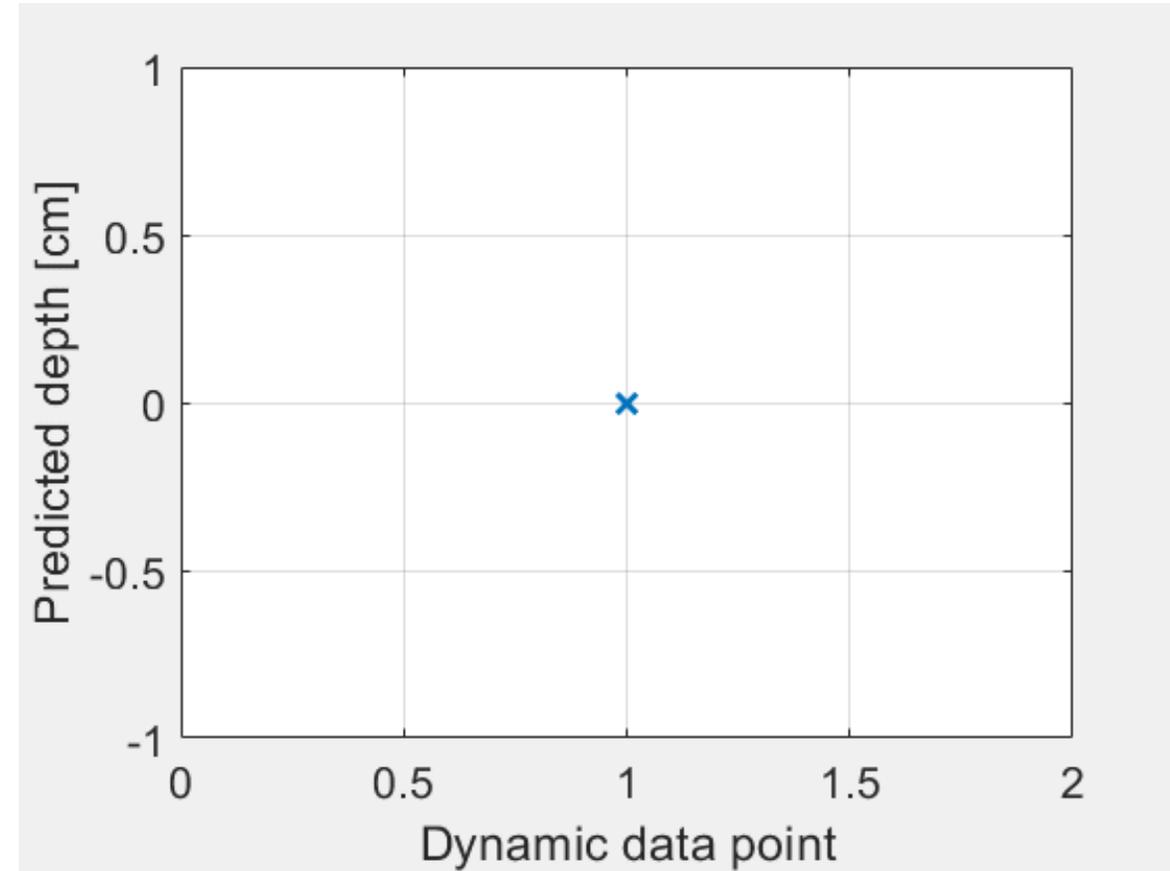
# Inverted depth



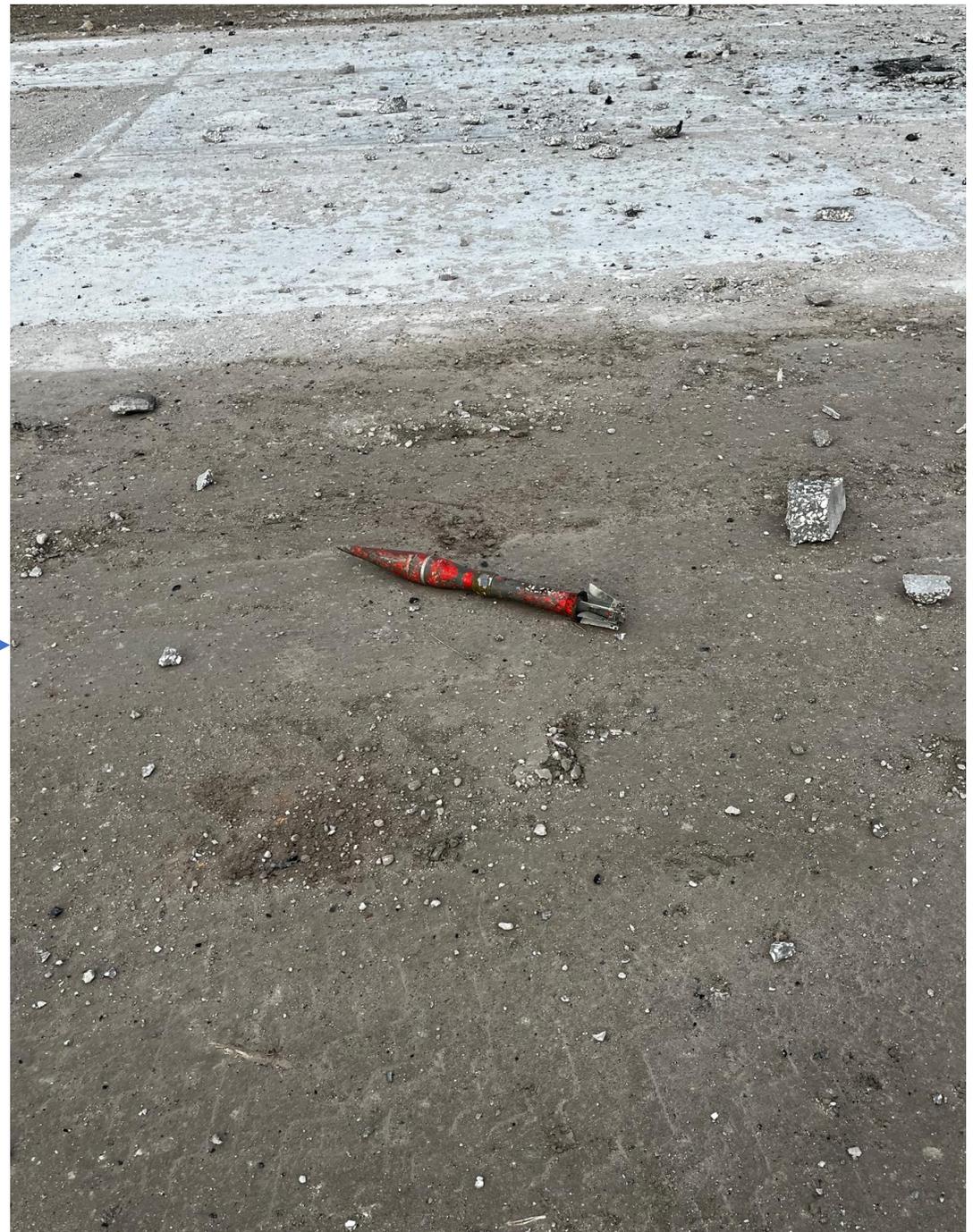
# Inverted polarizabilities



# Inverted depth



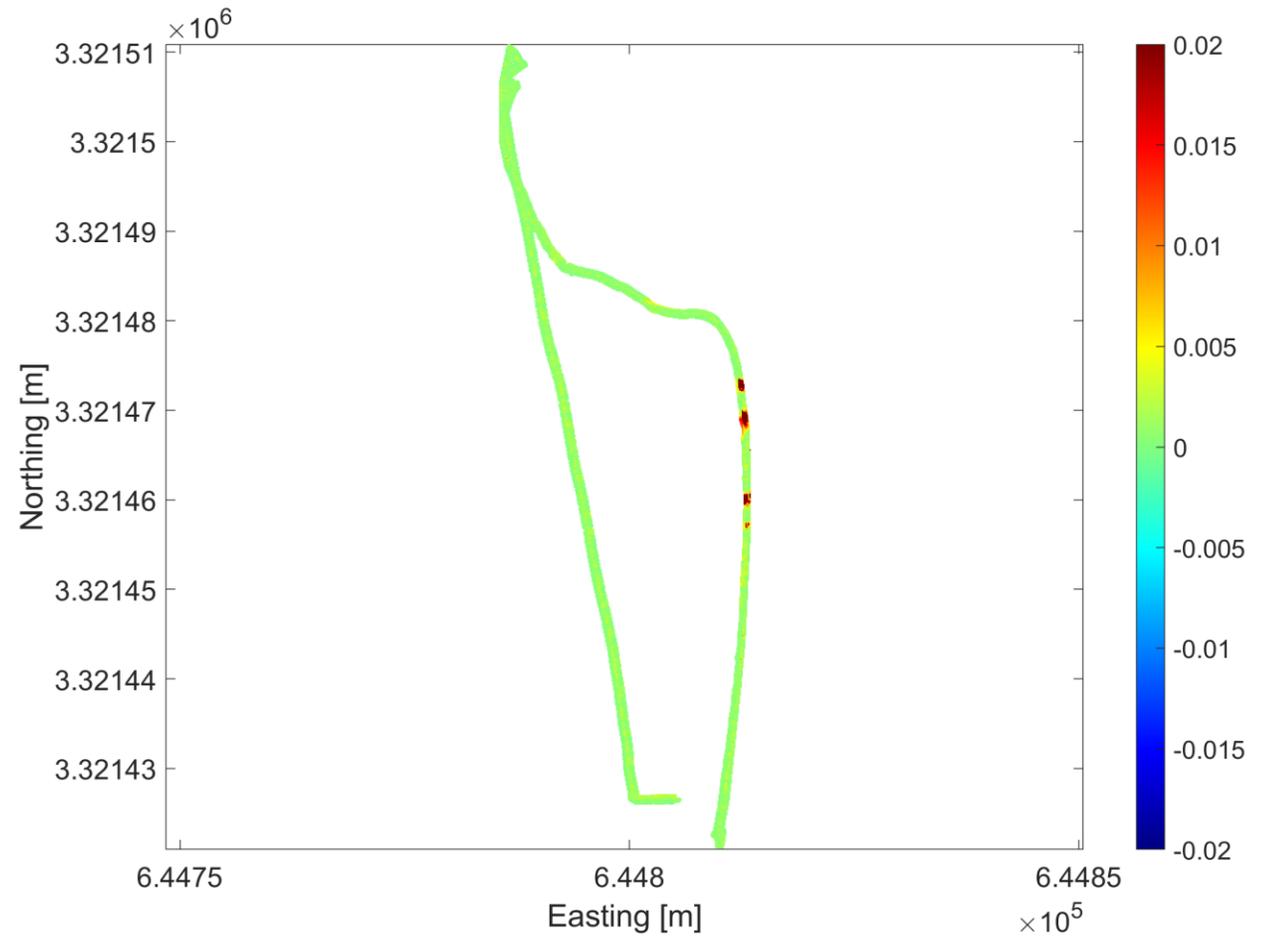
# Testing at Tyndall AF base



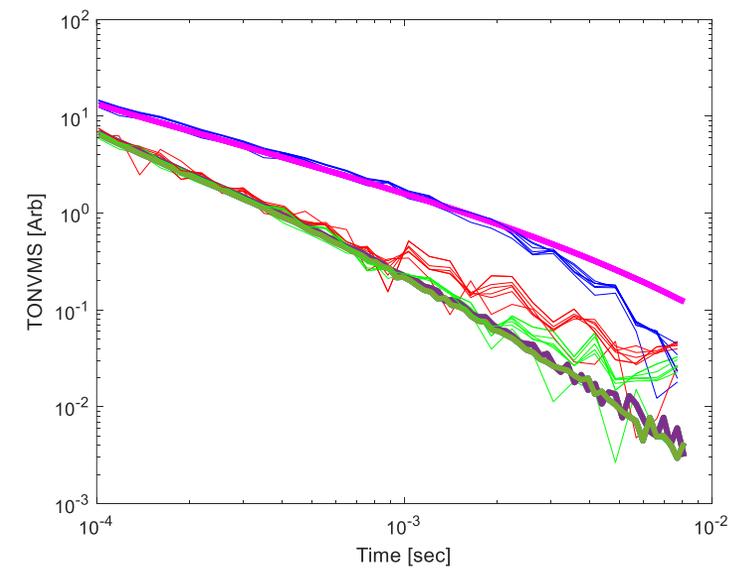
# Way points



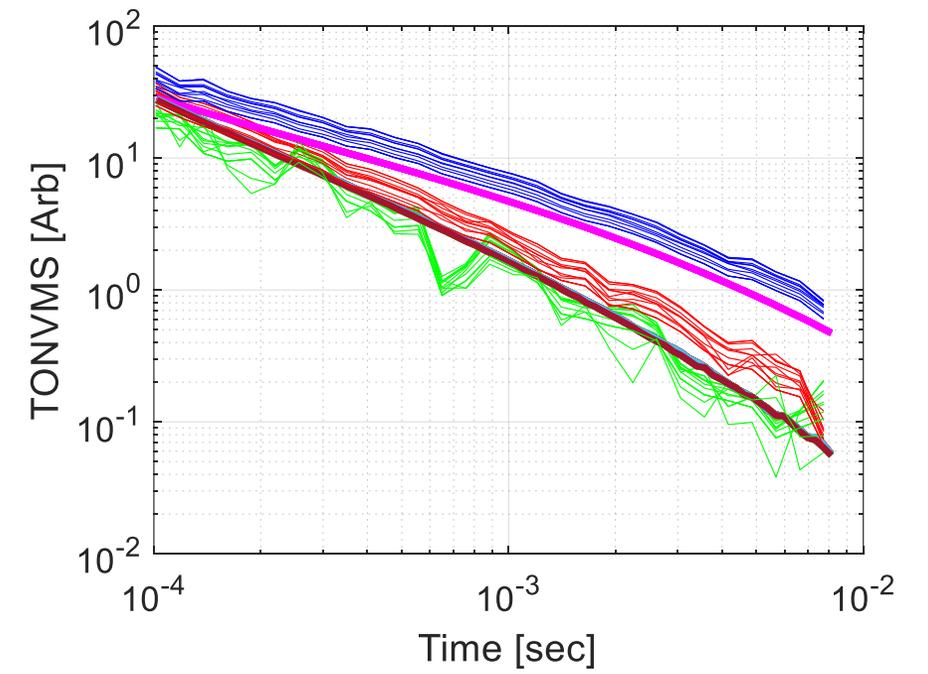
## Detection map



# 81 mm projectile



# Penetrator



# Conclusions:

- ULTRA-A system designed, built and test
- EMI data inversion and classification models were adapted to ULEMA-A
- UAS mounted EMI system was demonstrated

# Acknowledgments:

This work was supported by the AF Rapid Airfield Damage Assessment System (RADAS) program.

# Multi targets inversion

Measured depth 16 cm

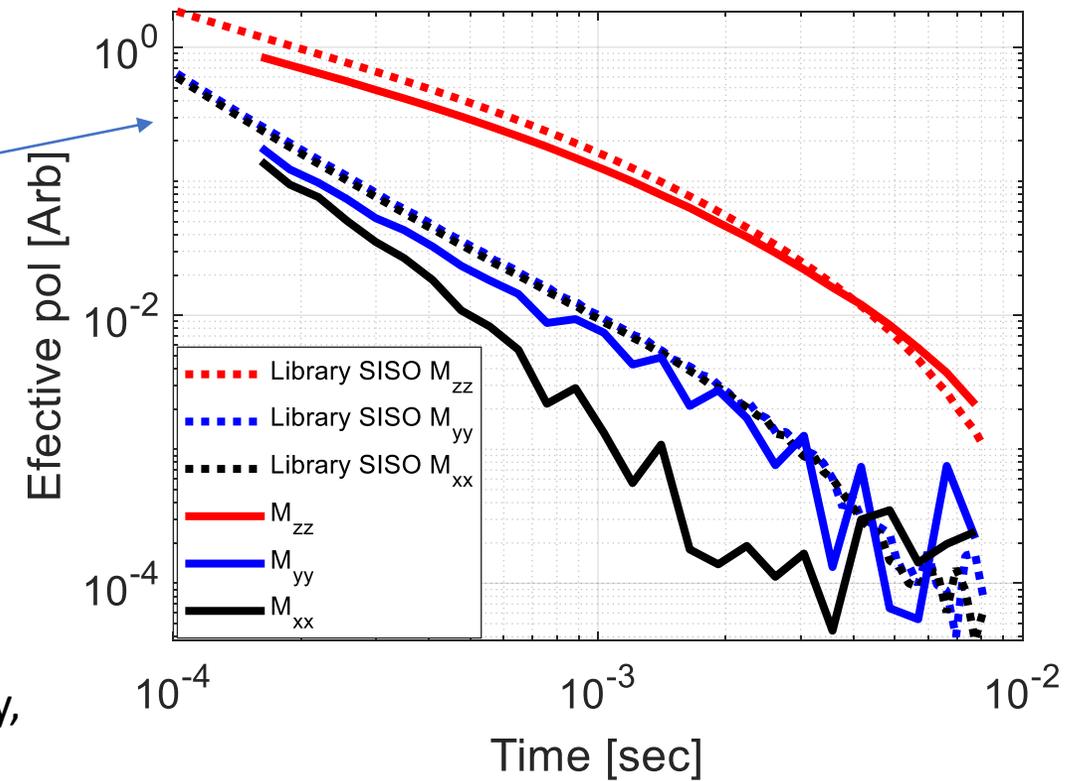
Estimated depth 20 cm

Measured lateral offset 5 cm

Estimated Lateral offset 0cm



$M_{zz}$ -primary,  
 $M_{yy}$ -secondary,  
 $M_{yy}$ -tertiary  
polarizabilities



# Multi targets inversion

Measured depth 110cm

Estimated depth 100 cm

Measured lateral offset 10cm

Estimated Lateral offset 30cm



$M_{zz}$ -primary,  
 $M_{yy}$ -secondary,  
 $M_{xx}$ -tertiary  
polarizabilities

