Robot-Mounted Ultra-Light Electromagnetic Array for Unmanned Unexploded Ordnance Detection and Classification

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Outline

- Motivation
- Sensor Descriptions
- Classification Process
- Data
- Conclusions and Next Steps

Focus

- Detection and discrimination of subsurface targets
- Using electromagnetic induction to identify targets
- Linking sensors to autonomous solutions

Work to Date

- Electromagnetic Sensing Group (EMSG) built MPV-I and MPV-II
- MPV systems are heavy and bulky

Solution

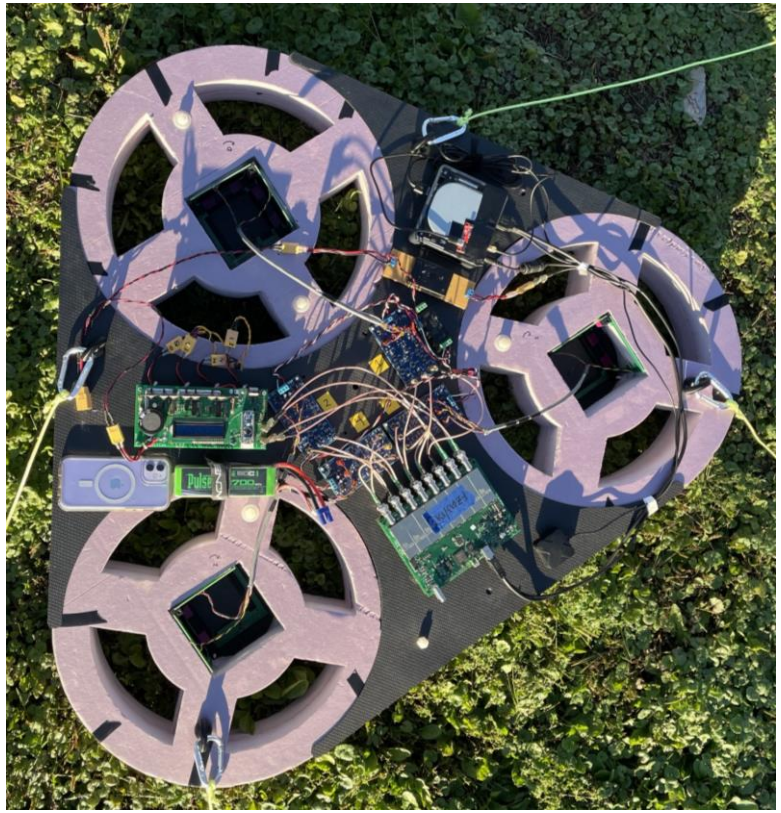
Ultralightweight Electromagnetic Array (ULEMA)

ULEMA-Handheld

- Addressing weight and maneuverability issues

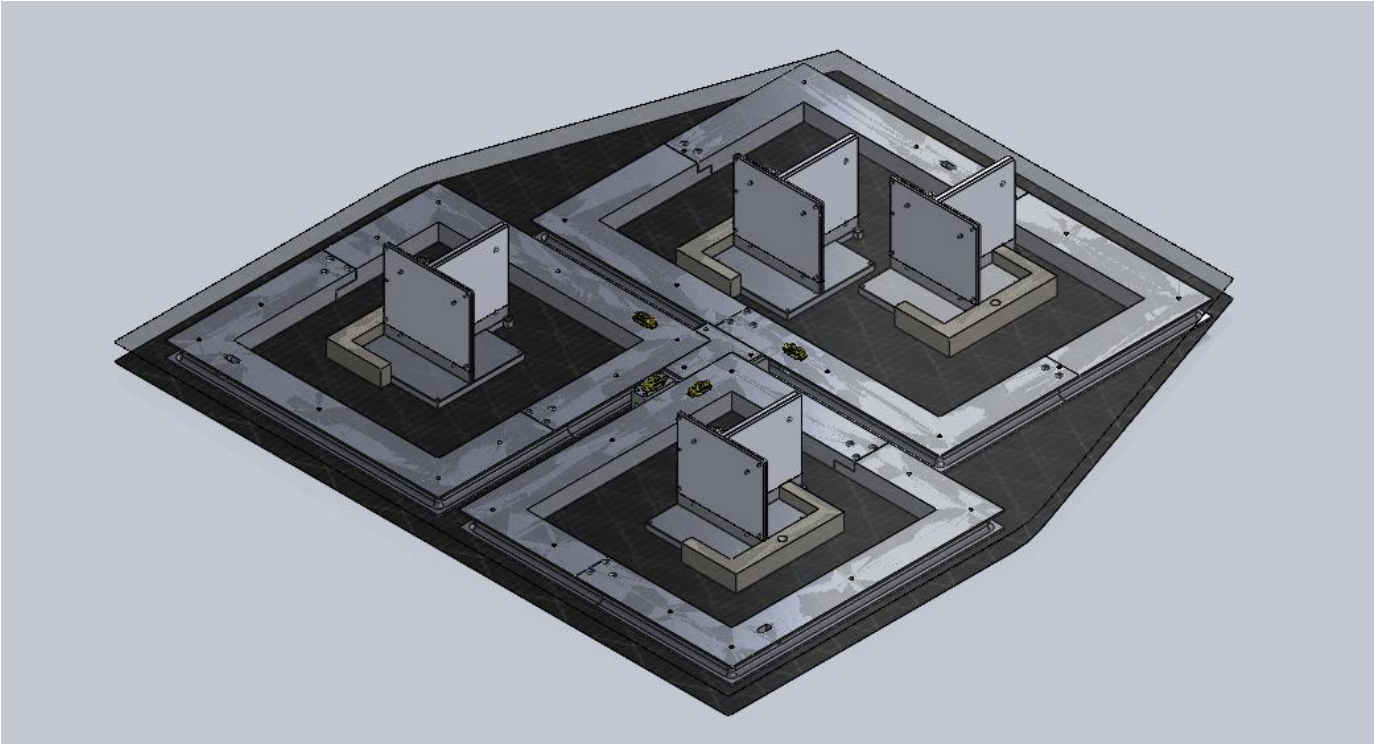
ULEMA-Air

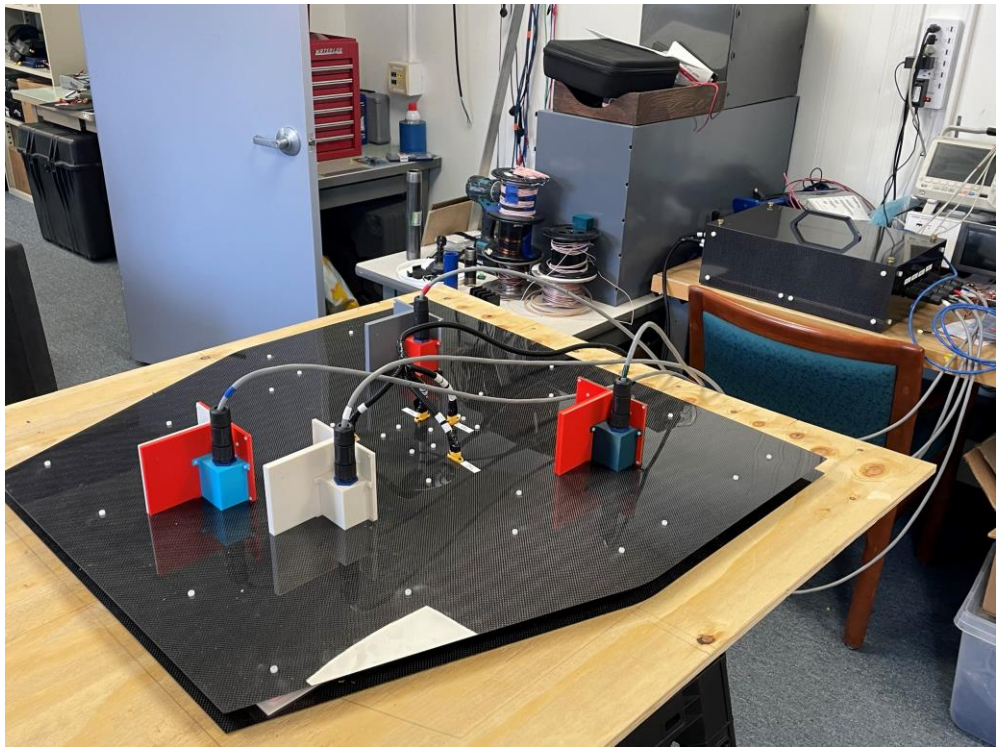
- Natural progression was to update ULEMA-Handheld to adapt for drone-borne capabilities



ULEMA-Robotic

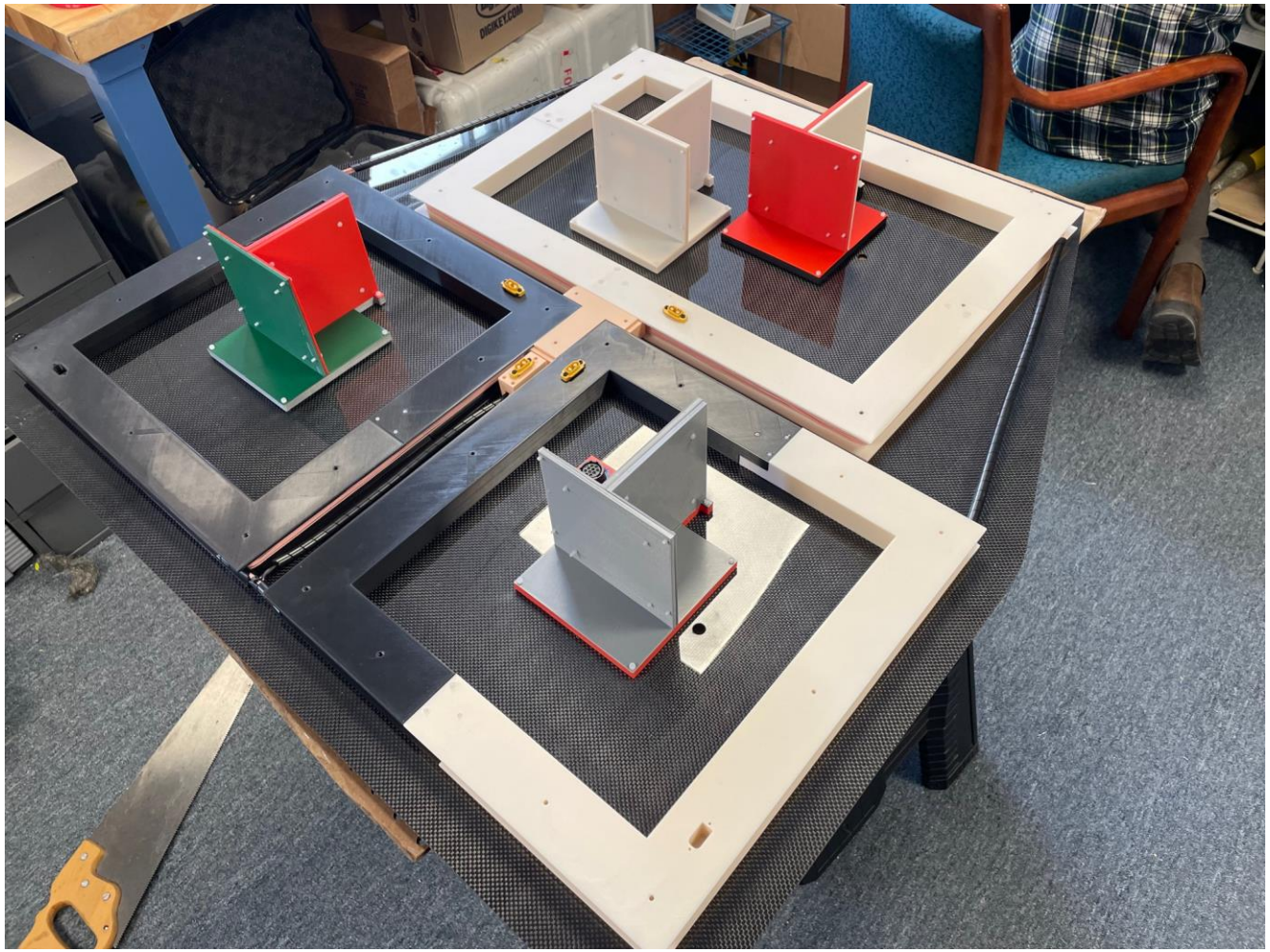
- Current path is mounting a ULEMA system to a robot





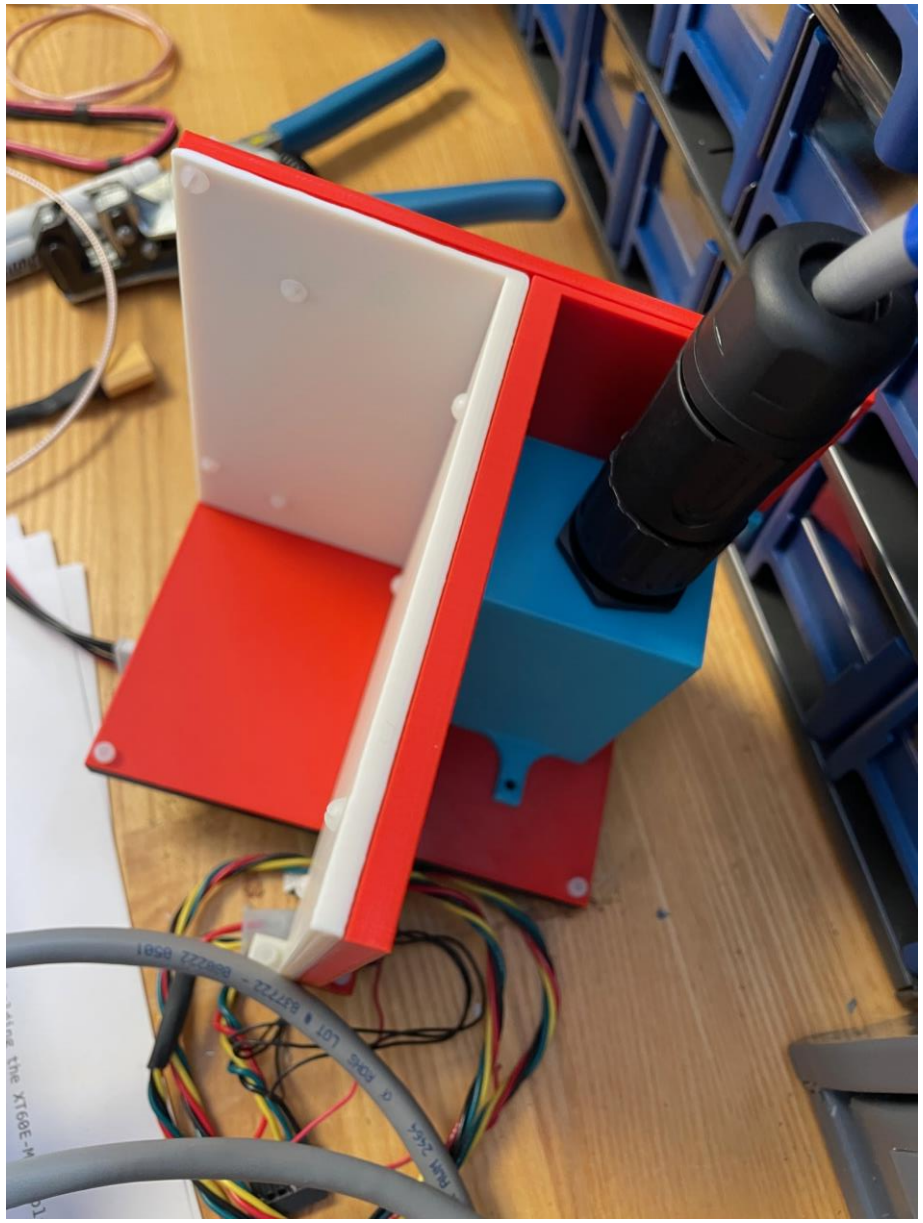
ULEMA-R Transmitters

- Four rectangular transmitter coils
- Inductance of ~530 uH



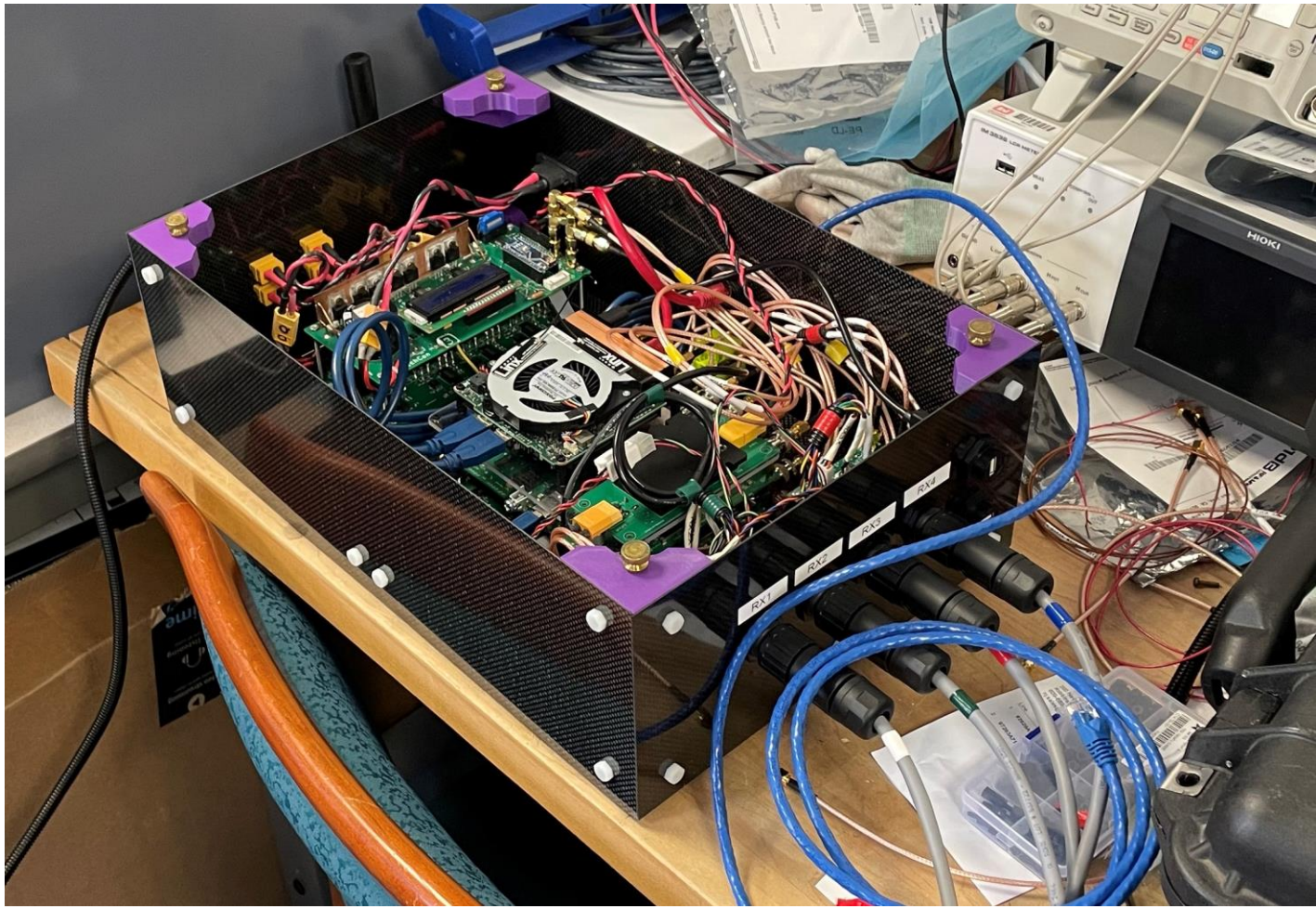
ULEMA-R Receivers

- Triaxial receiver configuration
- IP69 connector for receiver wires



ULEMA-R Electronics Box

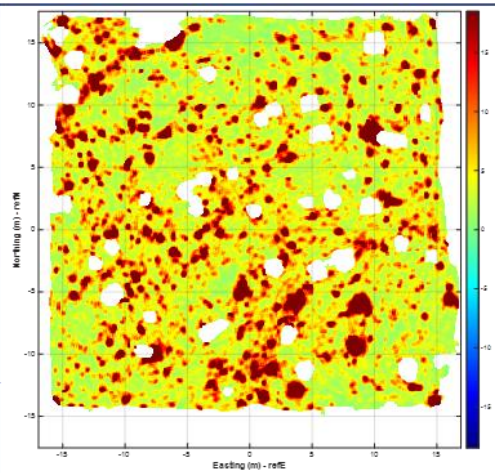
- Transmitter board providing 10A pulses of 8.33 msec
- NUC computer running Matlab
- Self-contained plugs
- Picoscope running at +/- 1V detection range



Three Step Classification Process

1. Data Acquisition

2. Data Inversion



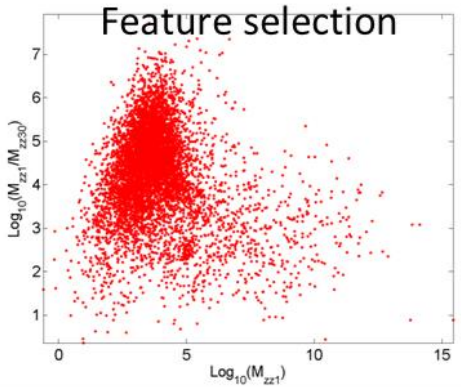
Forward Operator

$$d = F[p]$$

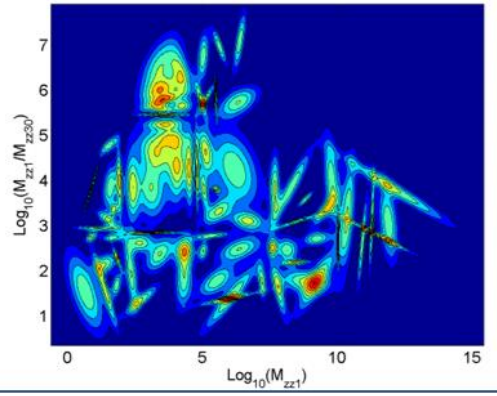
$$p = F^{-1}[d]$$

Inverse Operator

3. Decision



Clustering and Classification



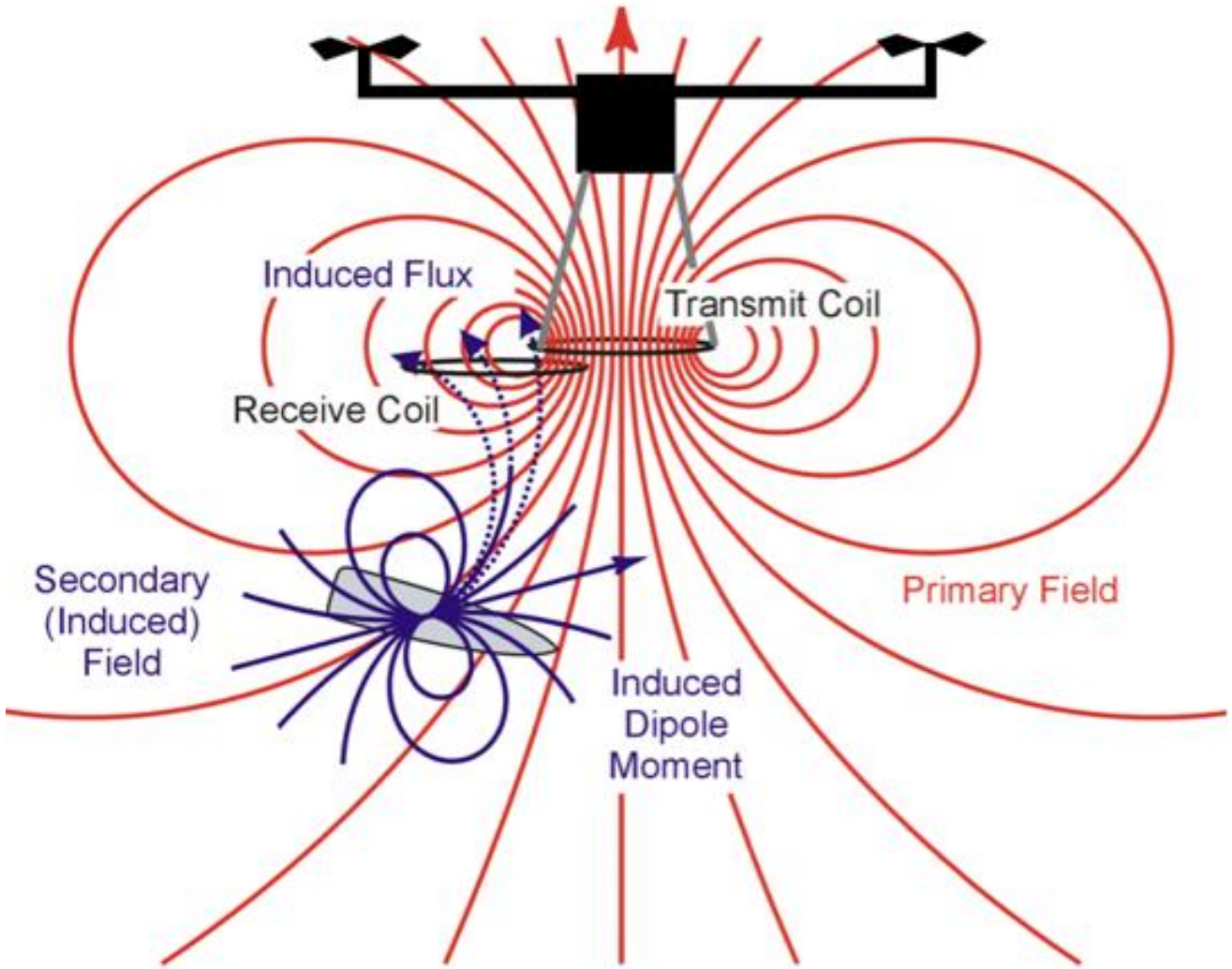
Background

$$\varepsilon = -N * \frac{d\Phi}{dt}$$

$$\Phi = B \cdot S$$

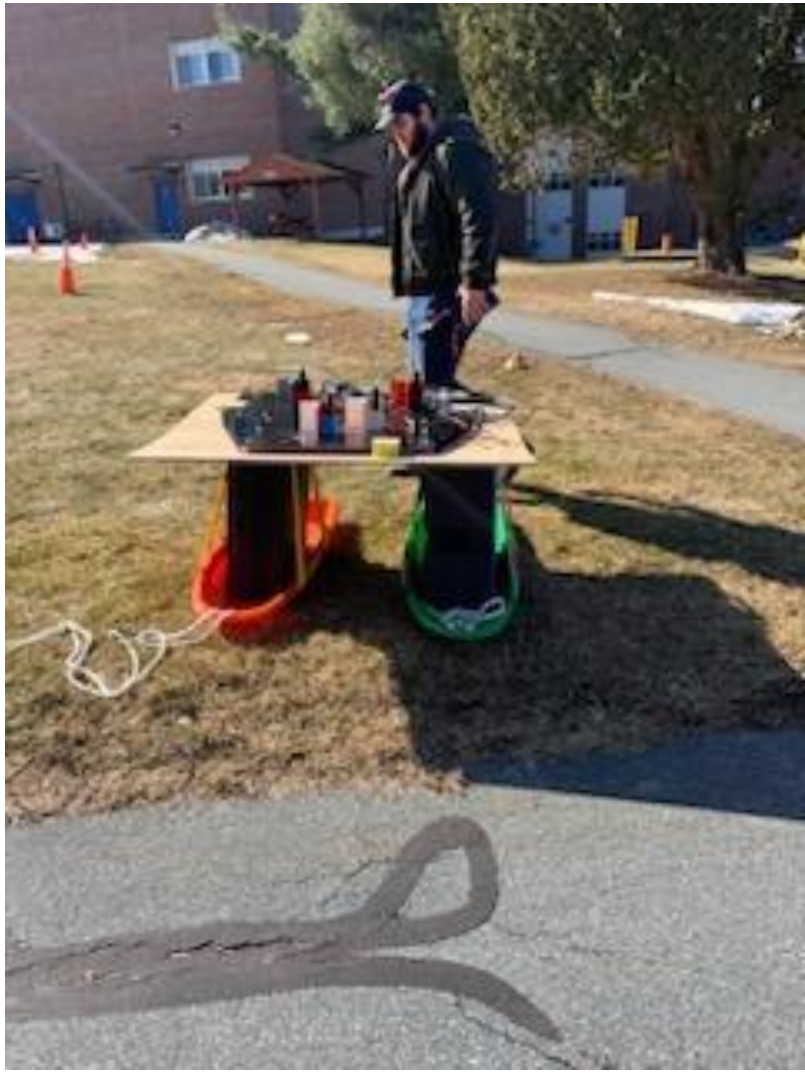
$$L = \frac{\mu * N^2 * A}{l}$$

$$B = \mu * \frac{N}{L} * I$$



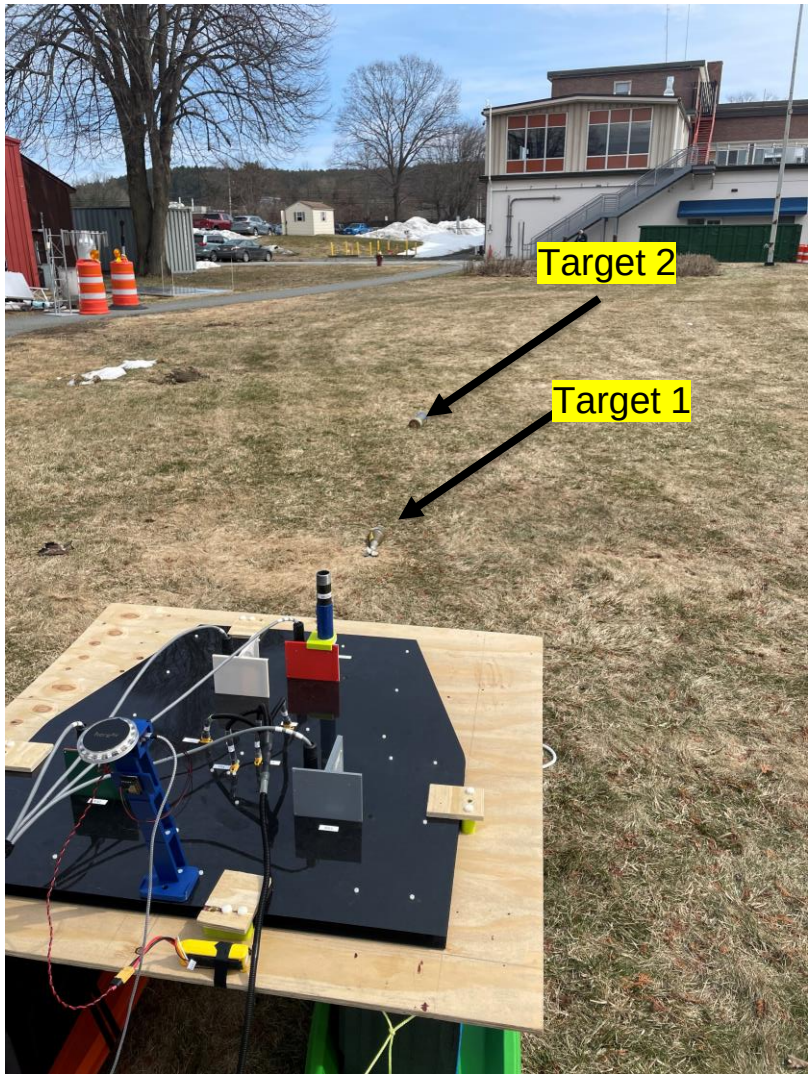
Dynamic Testing

- System raised on sleds
- Pulled across a set path, over targets



Sensor Results- Two target, Dynamic

- An 81mm projectile and a 105 mm projectile placed 2.6 m apart
- ULEMA-R pulled over the targets, a height of 56 cm above both



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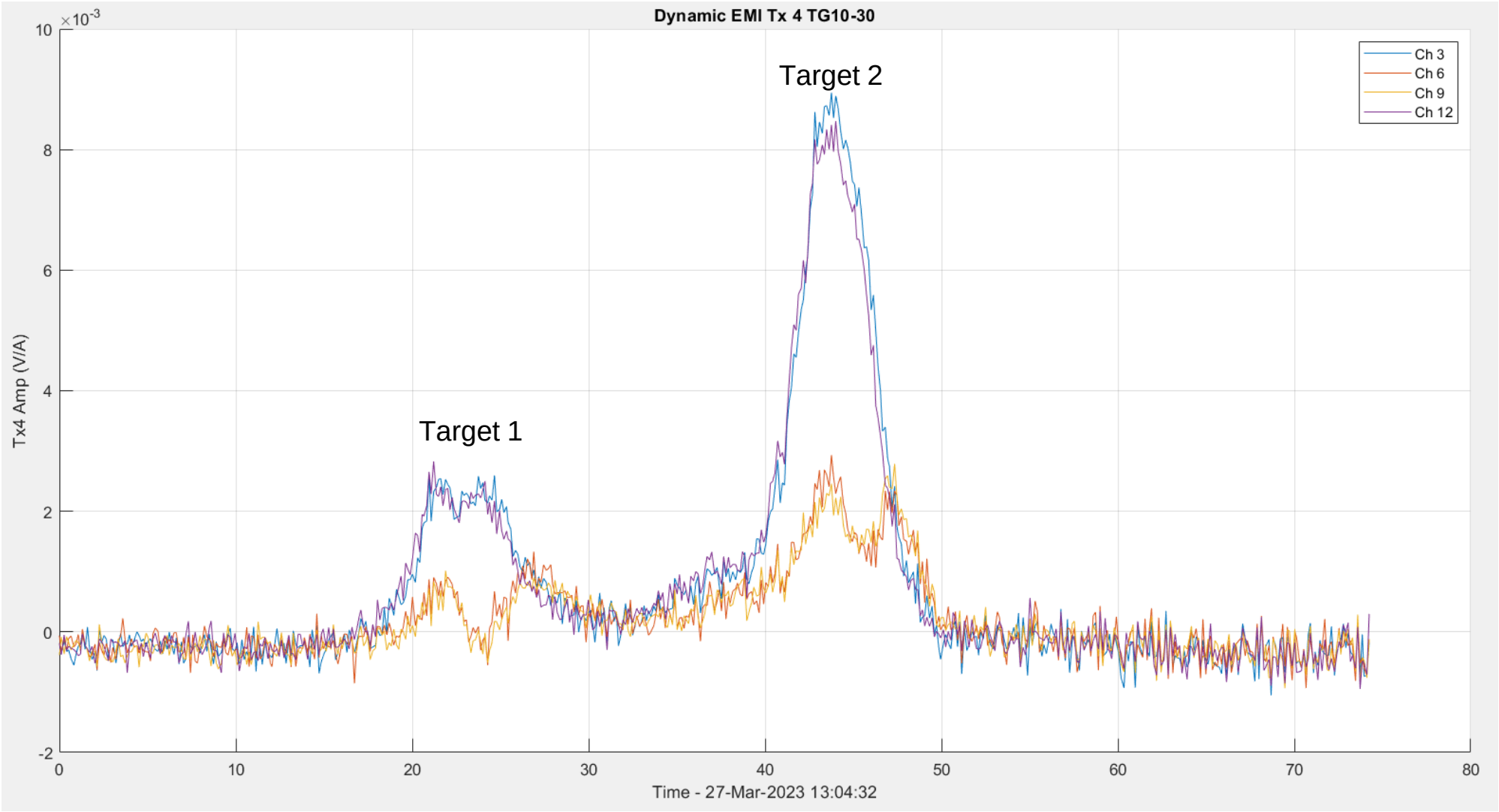

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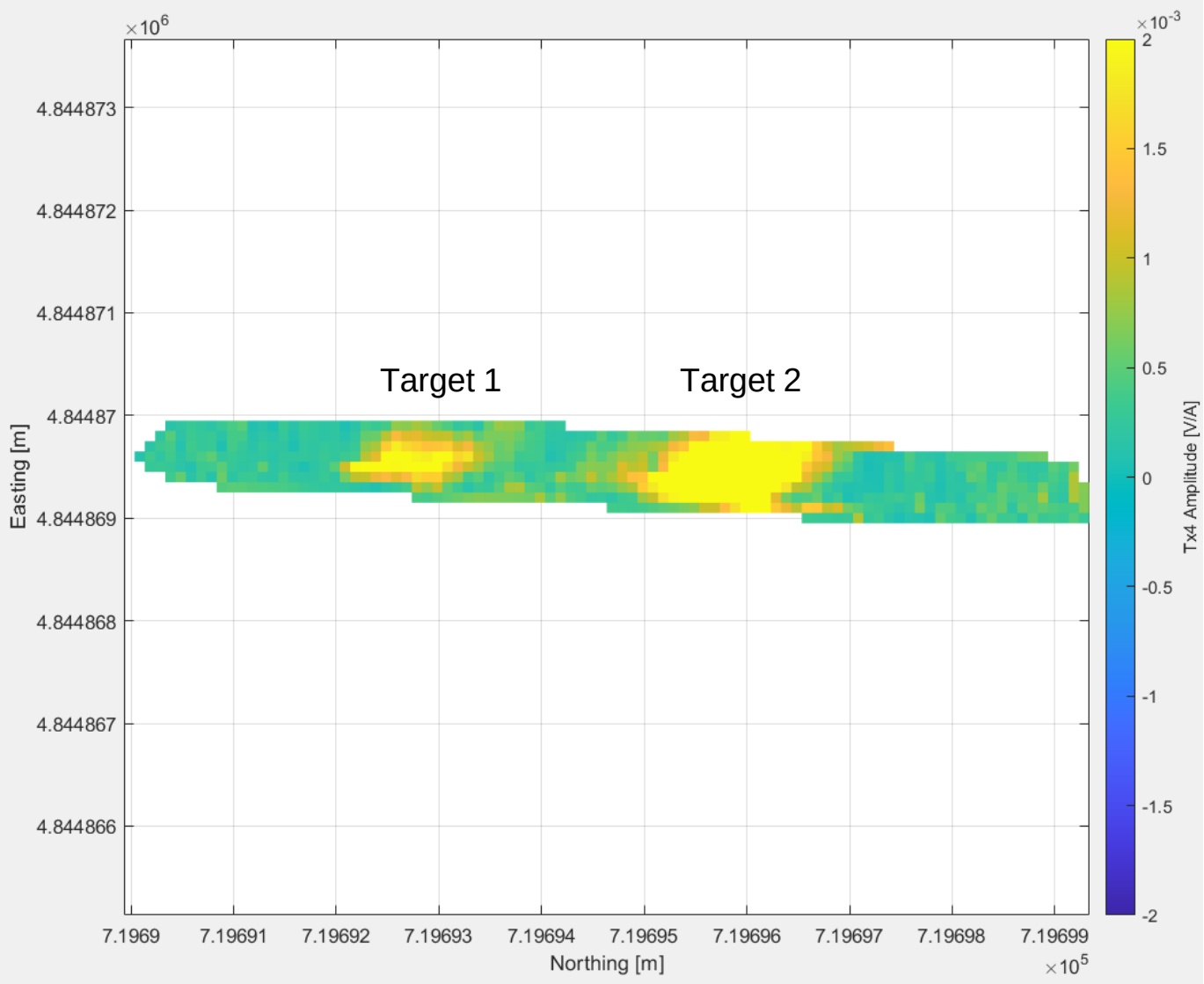
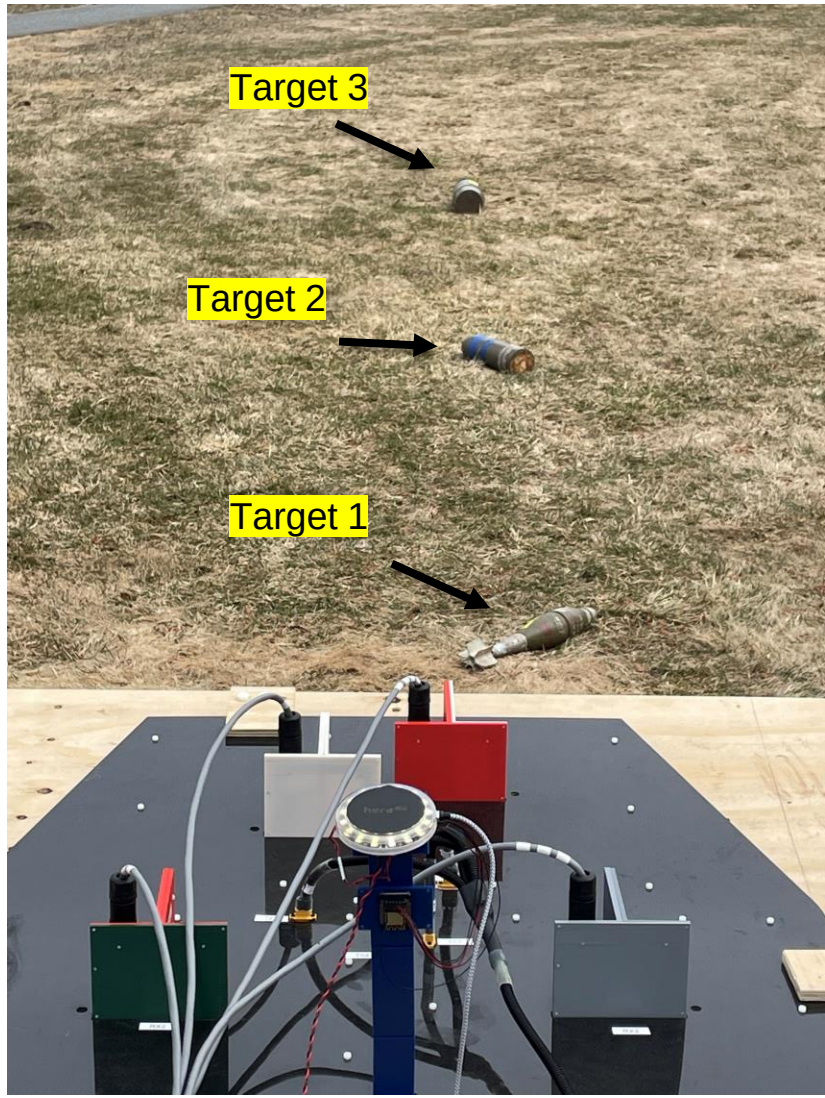


Sensor Results- Three target, Dynamic

- An 81mm projectile and a 105 mm projectile placed 2.6 m apart
- A 155 mm projectile placed 3 m behind the 105 mm
- ULEMA-R pulled over the targets, a height of 56 cm above both



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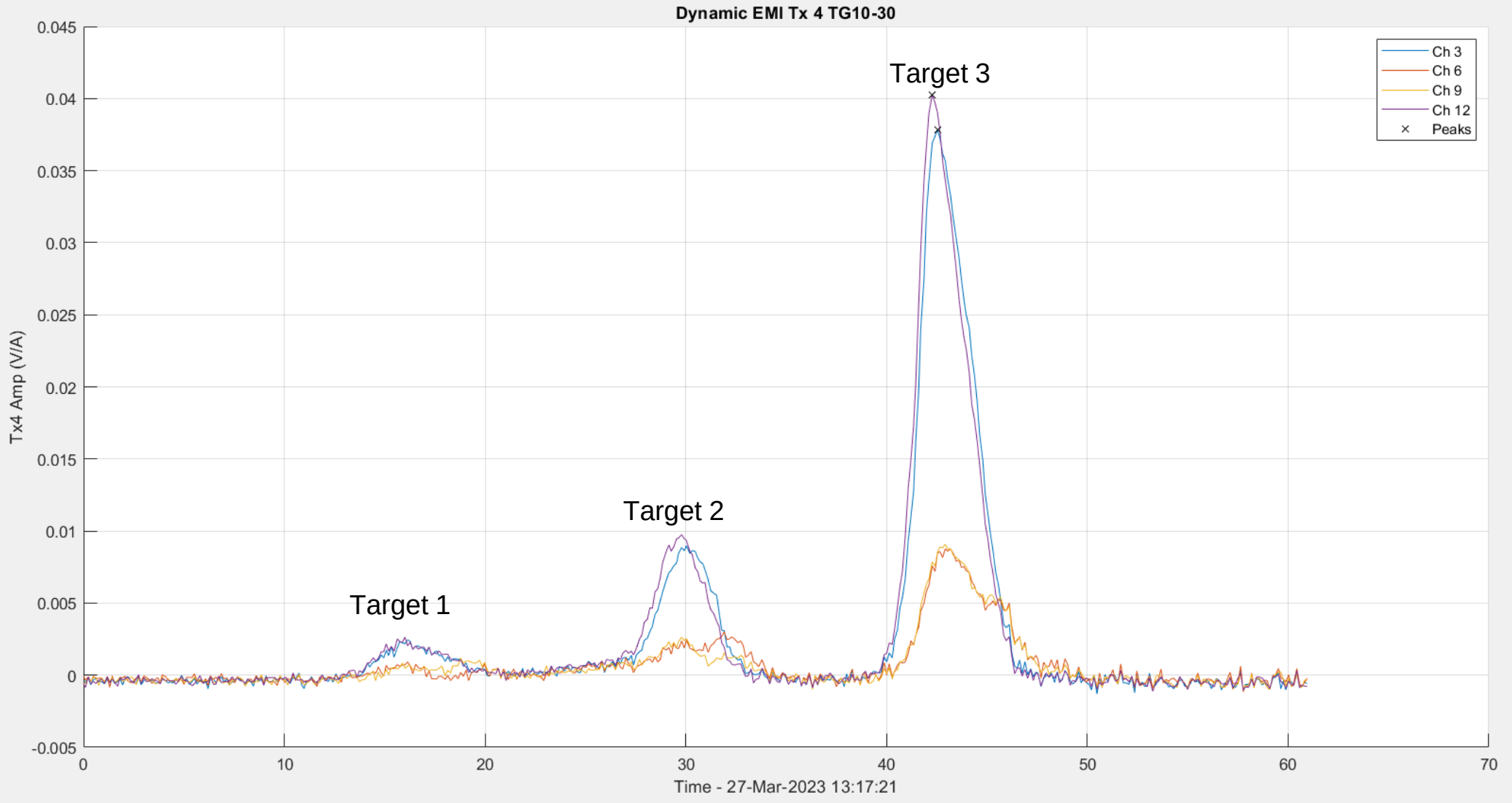

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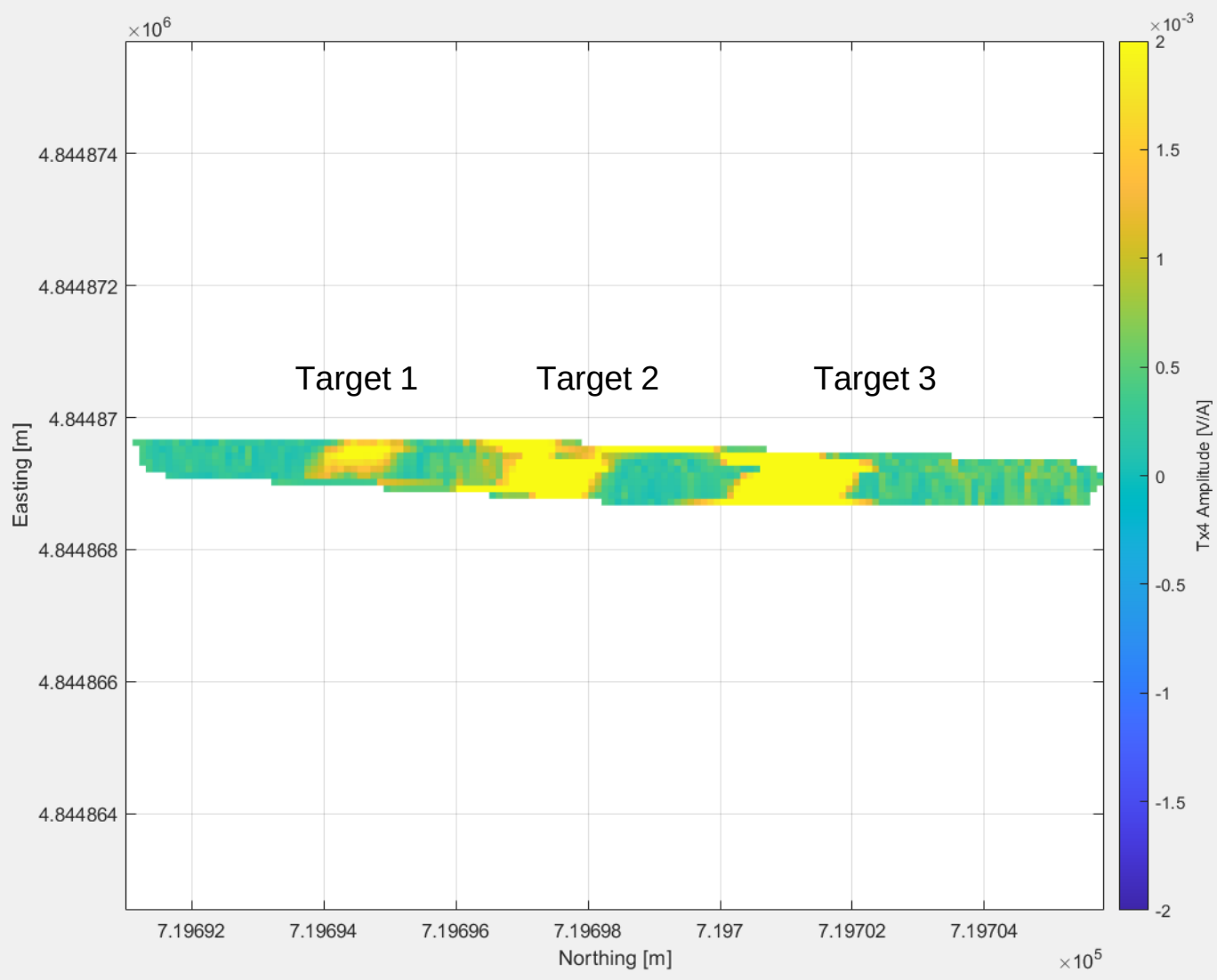
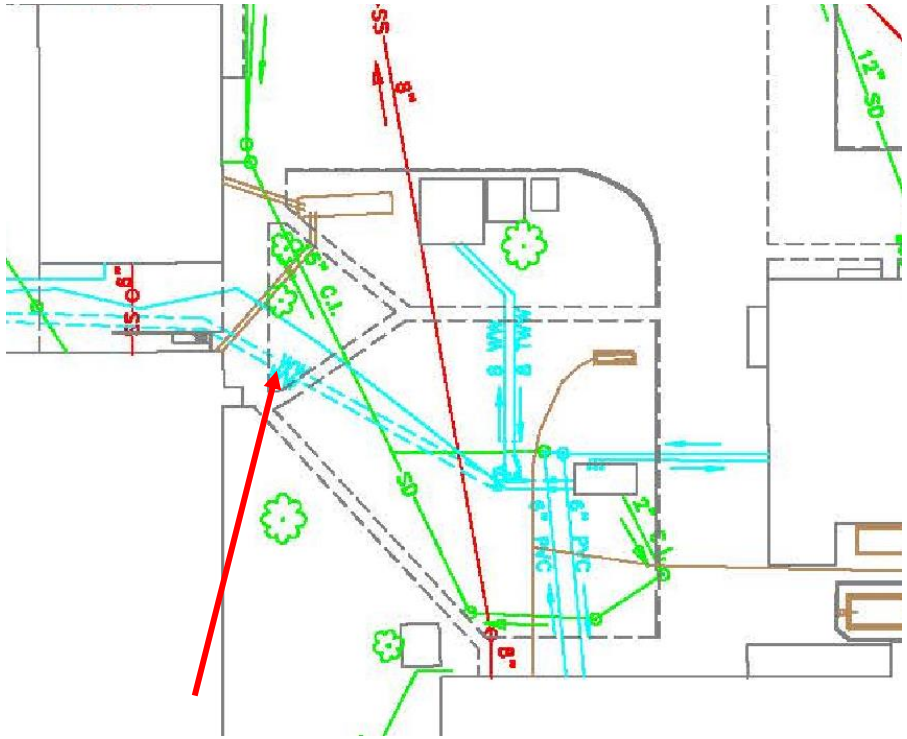
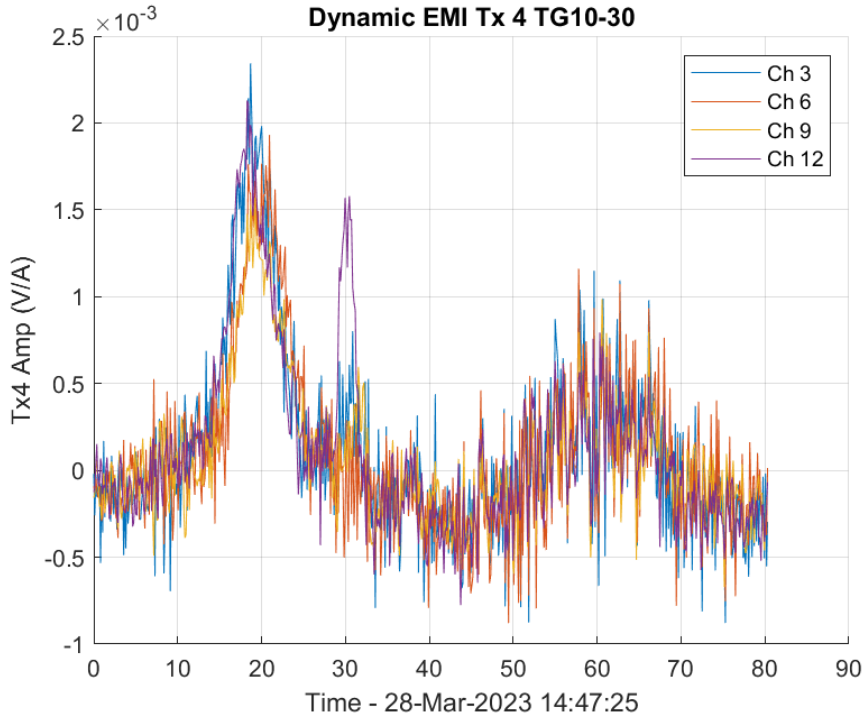


Additional Uses

- Can be used in utilities detection





Conclusions and Next Steps

- ULEMA-R is built and tested
- ULEMA-R can operate in both cued and dynamic modes
- Inversion algorithm has been developed and verified with cued and fully dynamic modes
- Data collection speed is 0.5 m/s
- Developing machine learning algorithms to aid in classification

Thank you!

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