

# Advanced geophysical classification for deeply buried ordnance in urban environments

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SAGEEP  
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# Presentation Overview

## SAGEEP 2023

**01** Introduction  
UltraTEM Borehole AGC

**02** Case Study:  
Friedenthal lock  
Oranienburg, Germany

**03** UltraTEM Borehole AGC  
Marine Deployment

**04** Target Excavation  
Challenges and Solutions

# Introduction

## UltraTEM<sup>®</sup> Borehole AGC

01



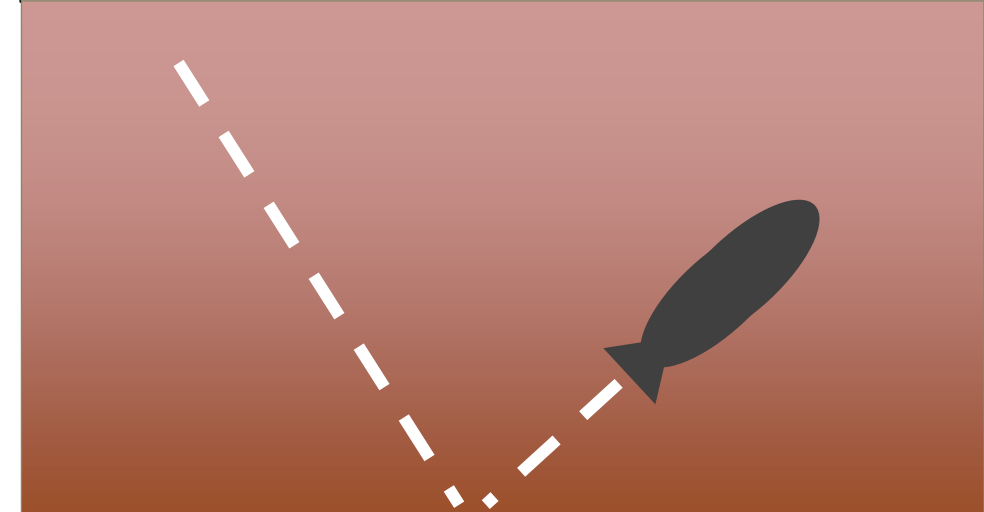
# UltraTEM<sup>®</sup> Borehole 2014 - Now

- GapEOD and BTG working with Heinrich Hirdes KMR since 2014
- 100's of sites in Oranienburg
- Challenging urban environments



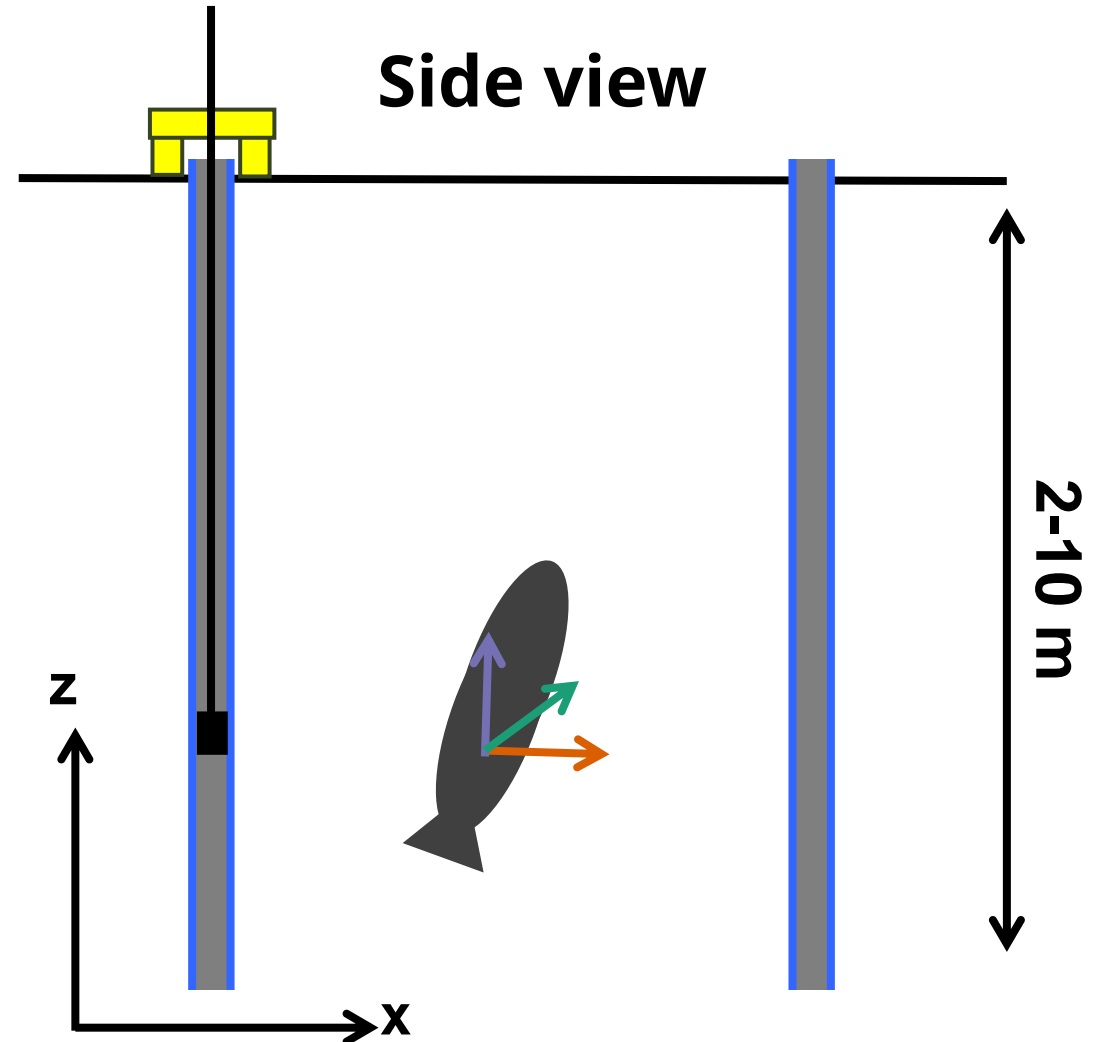
# UltraTEM<sup>®</sup> Borehole 2014 - Now

- GapEOD and BTG working with Heinrich Hirdes KMR since 2014
- 100's of sites in Oranienburg
- Challenging urban environments
- Undetonated bombs in nose-up orientation
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- UXO are deeper (5-10 m)
- No ordnance items missed
- AGC saves cost of digging



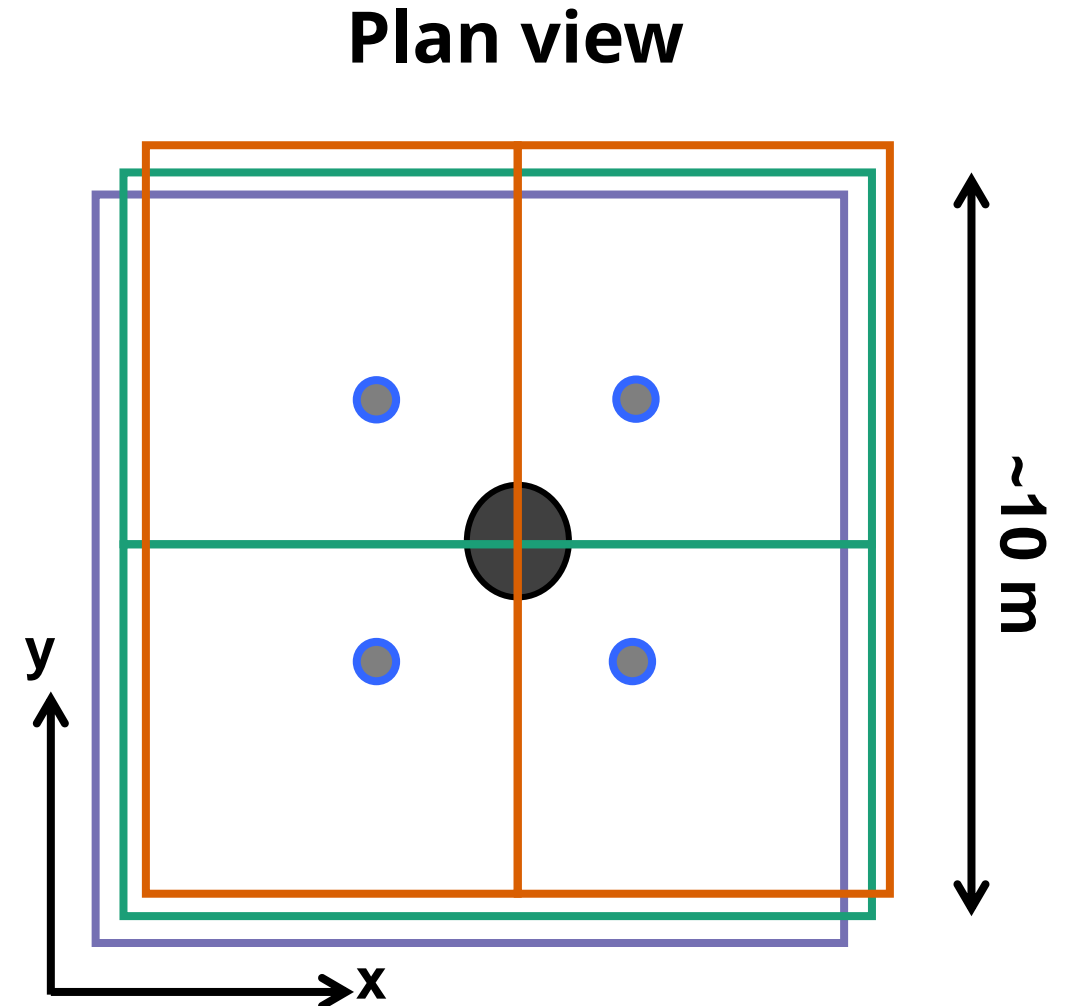
# Borehole Survey AGC

1. Preliminary quick magnetics survey
2. Identify anomalies for AGC
3. Large, high current (170A) transmitter loops
4. Long off-time fluxgate magnetometer receiver at depth



# Borehole Survey AGC

1. Preliminary quick magnetics survey
2. Identify anomalies for AGC
3. Large, high current (170A) transmitter loops
4. Long off-time fluxgate magnetometer receiver at depth
5. 4-7 Boreholes for each target
6. 3 x loop geometries



# Case Study: Friedenthal lock

02







# Friedenthal Lock History

- 1<sup>st</sup> lock built in 1788
- 2<sup>nd</sup> lock built in 1879
- Connection between Ruppiner Canal & Oranienburg Havel
- Destroyed in WWII
- Closed until present
- Planned Upgrade to allow for access



# Friedenthal Lock History



After the bombing



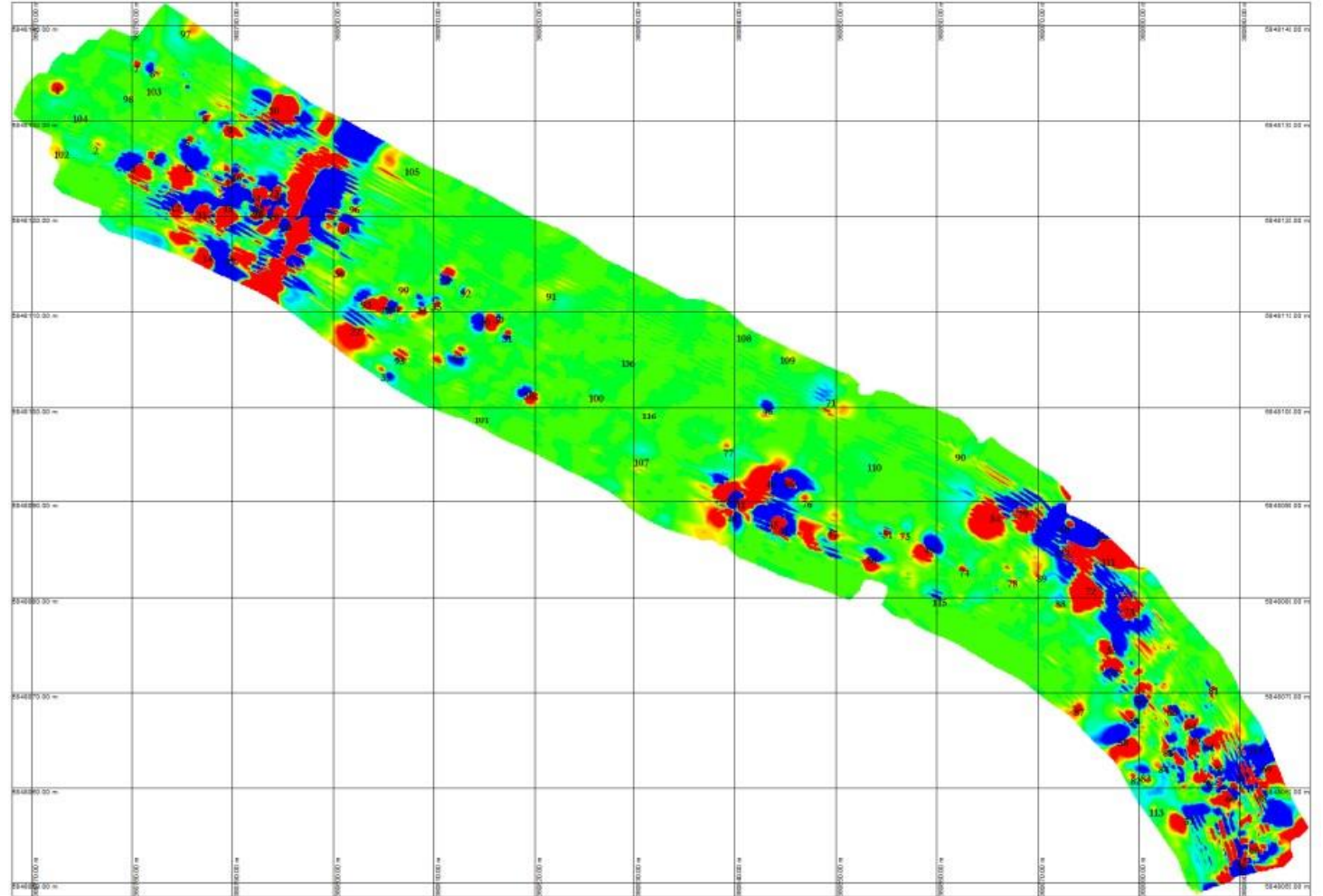
Before the bombing

# Survey Stage 1 EO Cleanup

Marine Magnetics to  
identify and clear 0-2 m

## Survey Area

- 2,900 m<sup>2</sup> (0.7 ac)
- 337 Targets



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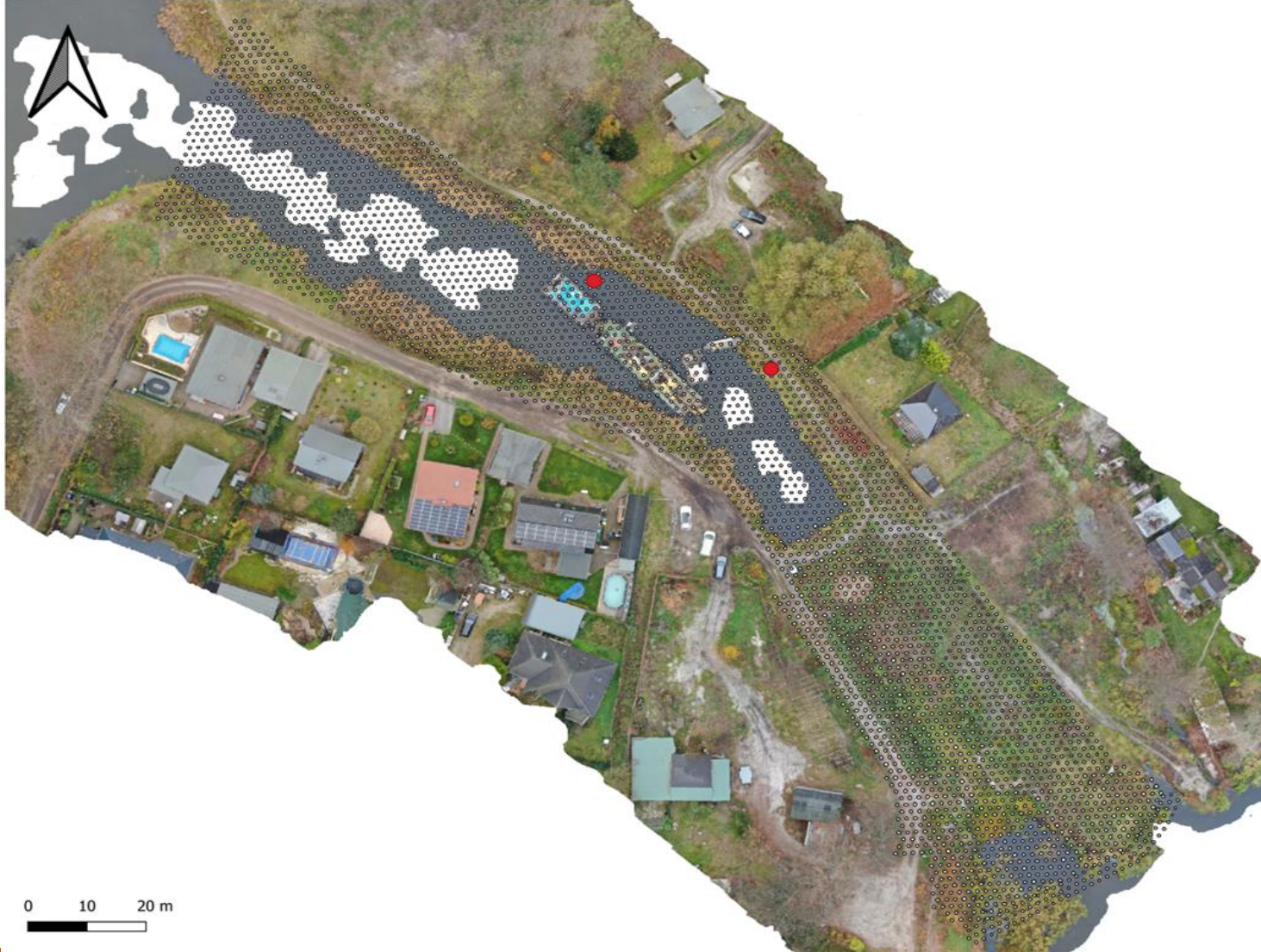
- 2,900 m<sup>2</sup> (0.7 ac)
- 337 Targets

Recovery of near-surface anomalies:

- 116 pcs recovered
- 5 pcs ammunition



# Survey Stage 2 Boreholes



## Objectives:

- 3-axis Magnetometer BH
- Detect large-caliber UXO
  - > 100 lbs
  - < 12.0 m below terrain level
- Detect large UXO fragments
- Cone Penetration Test (CPT) for geotechnical info
- Measuring depth 9.5 – 12.5 m

0 10 20 m

# Survey Stage 2

## Boreholes



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### Boreholes Surveyed

- CPT : 1985
- Magnetics (3-Axis): 763

# UltraTEM<sup>®</sup> Borehole AGC

## Marine Deployment

03





# UltraTEM® Borehole Marine Deployment

Worlds 1st Marine UltraTEM®  
borehole measurement.

- Floating Pontoon: 100 m<sup>2</sup>
- 4 UltraTEM Anomlaies
- 7 Boreholes per anomaly



Anomaly 2

# UltraTEM<sup>®</sup> Borehole Marine Deployment

Worlds 1st Marine UltraTEM<sup>®</sup>  
borehole measurement.

- Floating Pontoon: 100m<sup>2</sup>
- 4 UltraTEM Anomlaies
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Results:

2 x Classified as UXO

2 x No Dig

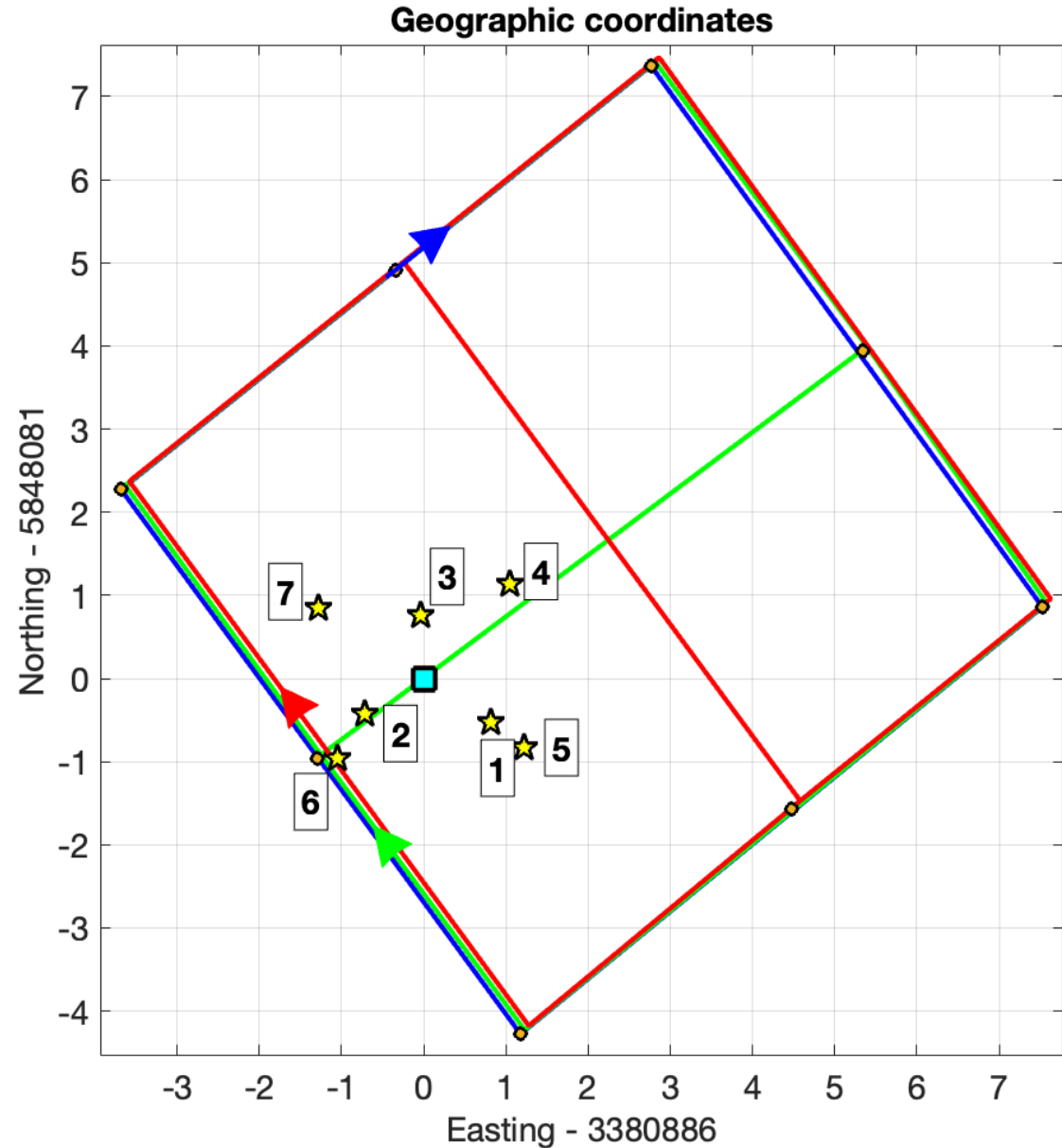


Anomaly 4

# Anomaly 1

## Survey Geometry

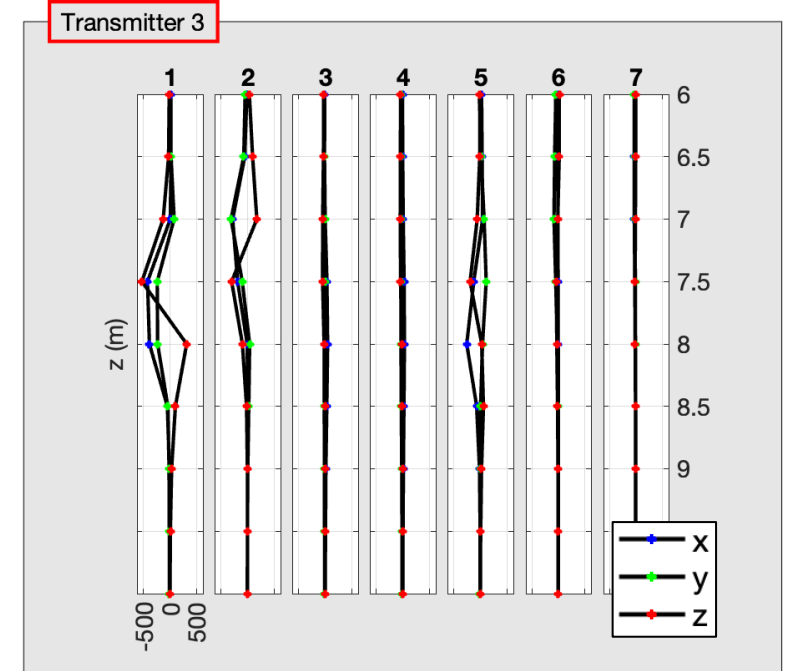
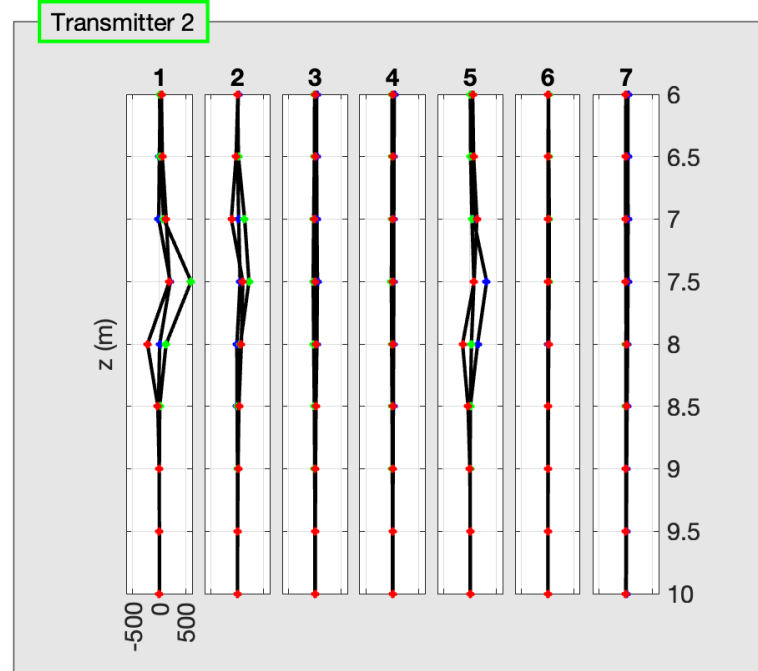
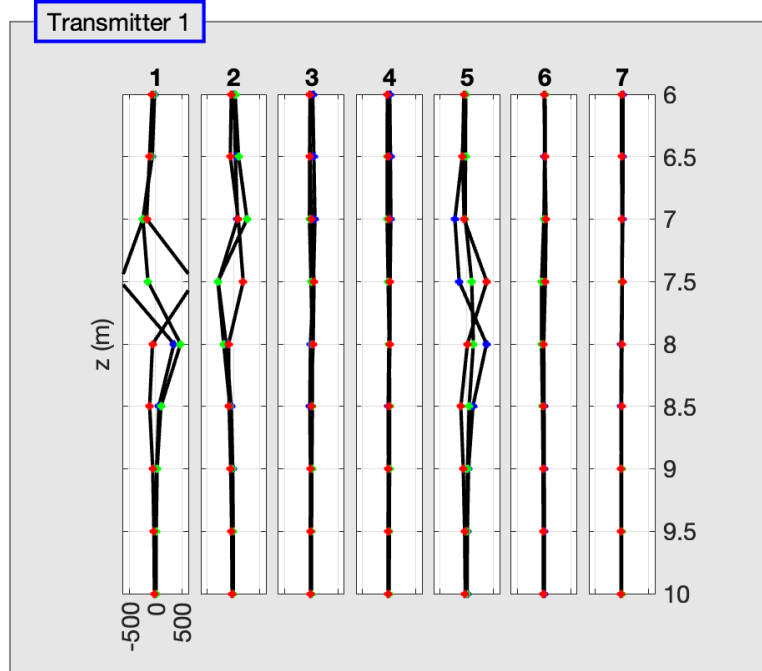
- Edge of canal, anomaly not well centered in loops.
- “Close” boreholes (1-3) at 0.75 m distance from expected target location are measured for detection of small or deep targets that may not be seen in boreholes farther away (4-7).



# Anomaly 1

## Observed Data

Observed UltraTEM borehole soundings (pT/A) at 2 ms time channel

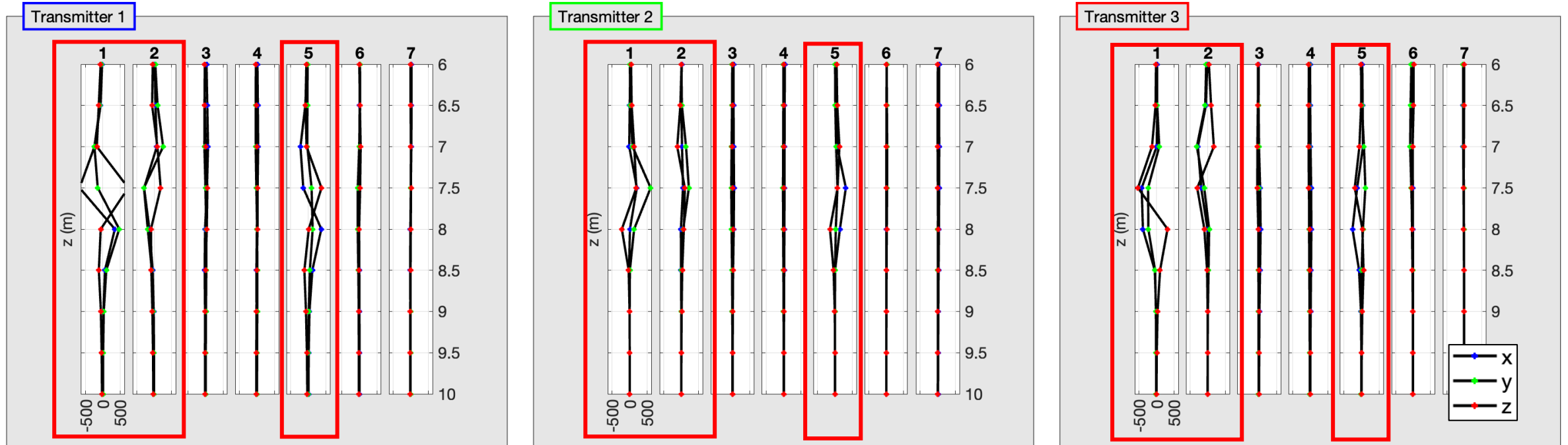


Vertical (z) field loop

Horizontal (x,y) field loops

# Anomaly 1, Observed Data

Strong dipolar anomalies in boreholes 1, 2, & 5 at approximately 7.5 m depth

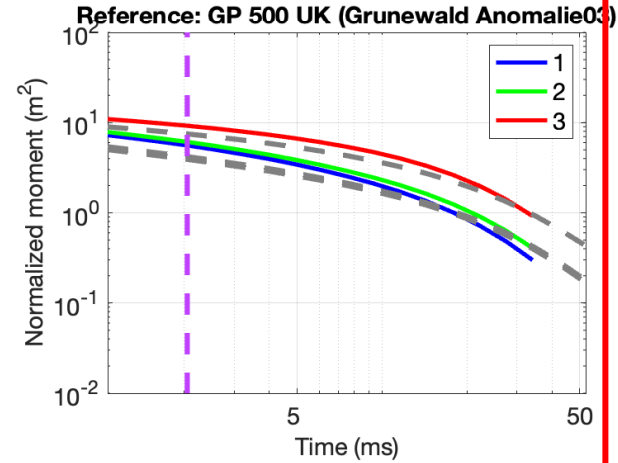
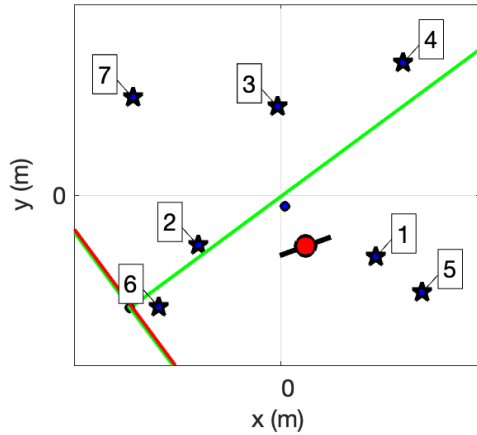


Vertical ( $z$ ) field loop

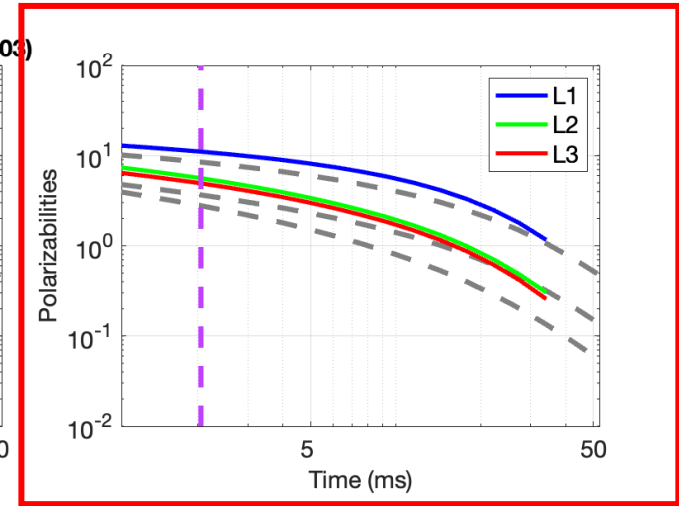
Horizontal ( $x,y$ ) field loops

# Anomaly 1 Inversion Result

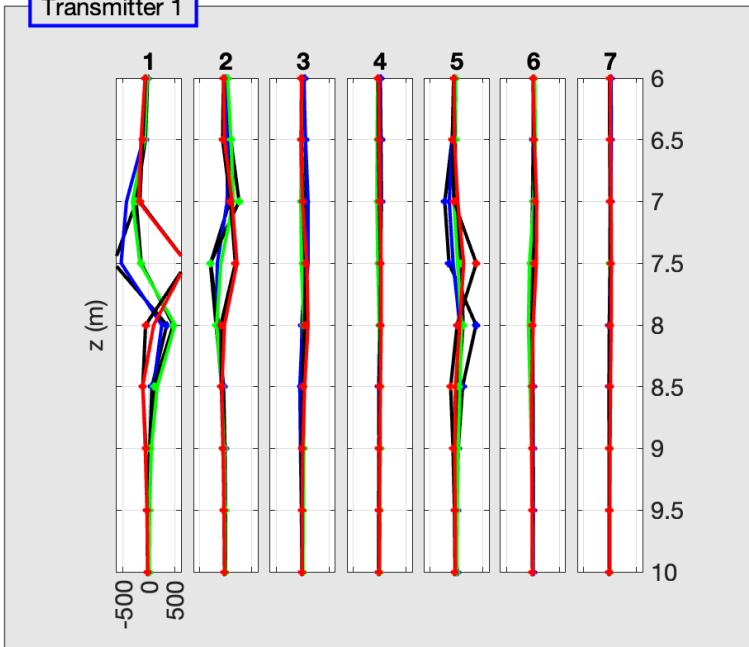
Friedenthaler-Schleuse-A1.dat,  $z_{est} = 7.72$  m



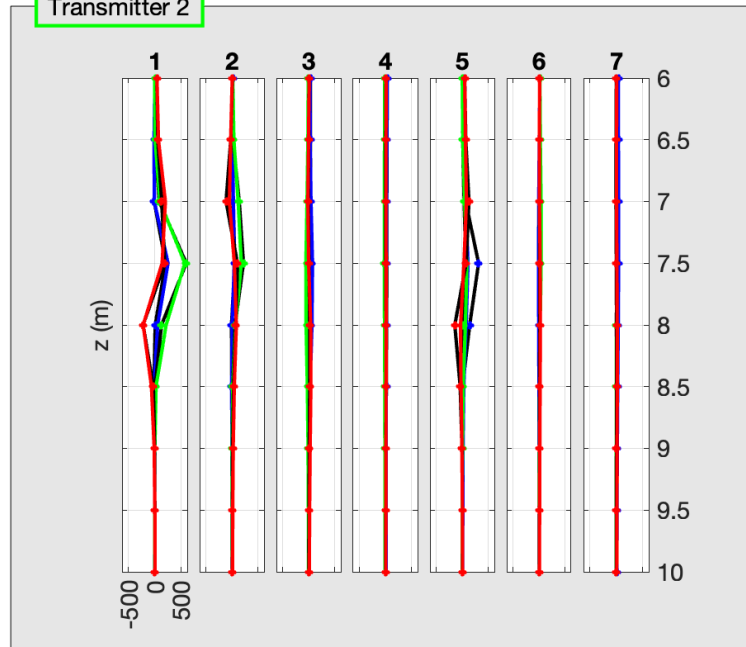
Likely UXO



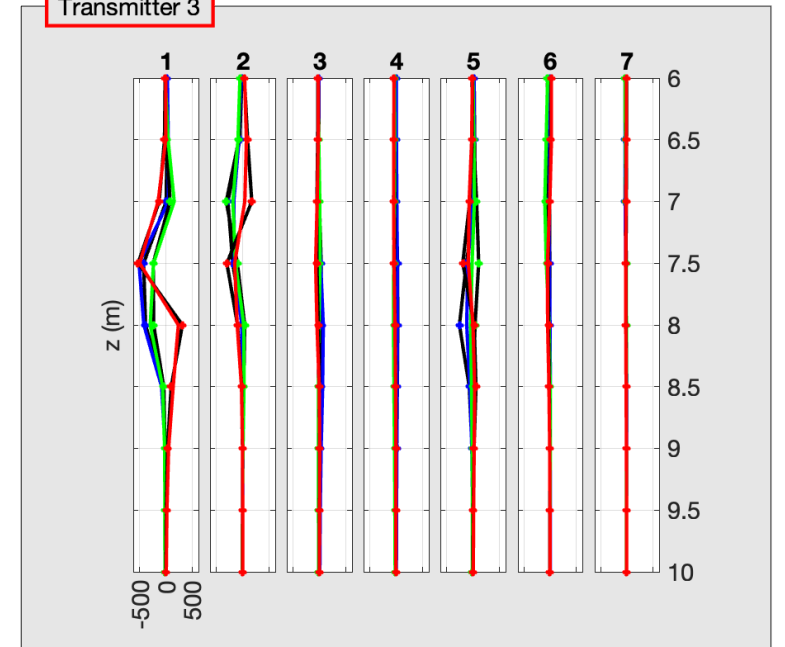
Transmitter 1



Transmitter 2



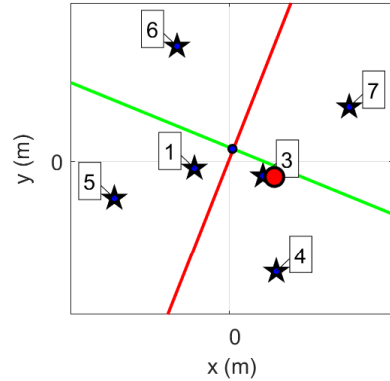
Transmitter 3



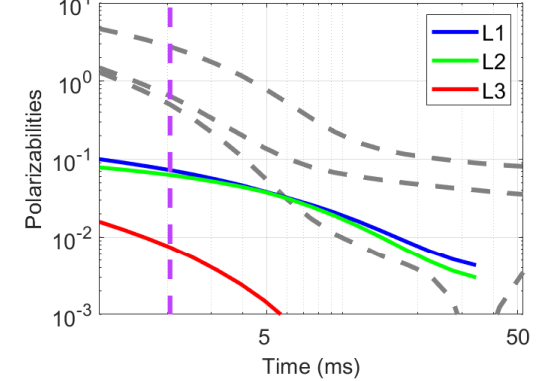
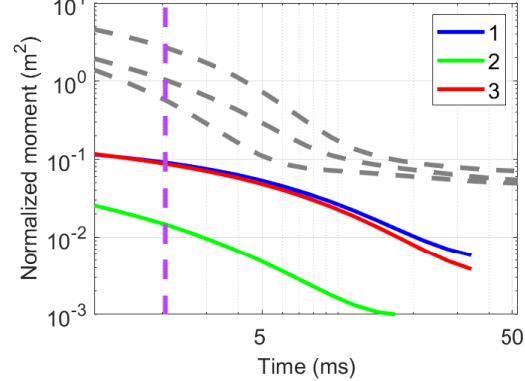
# Anomaly 4

## Inversion Result

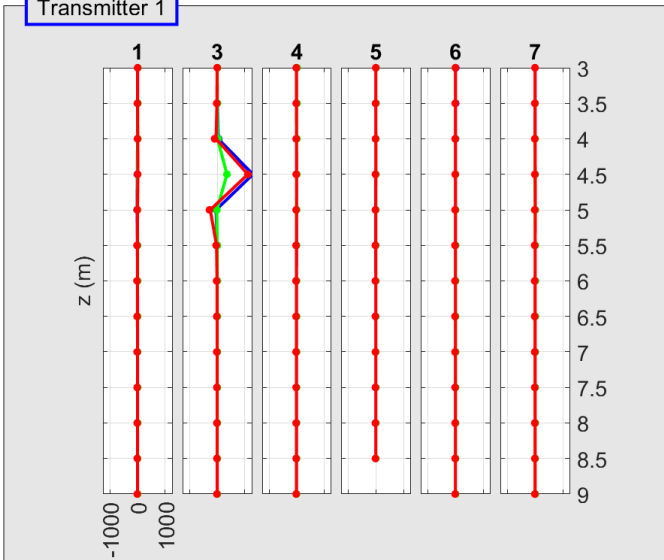
Friedenthaler-Schleuse-A4.dat,  $z_{est} = 4.65$  m



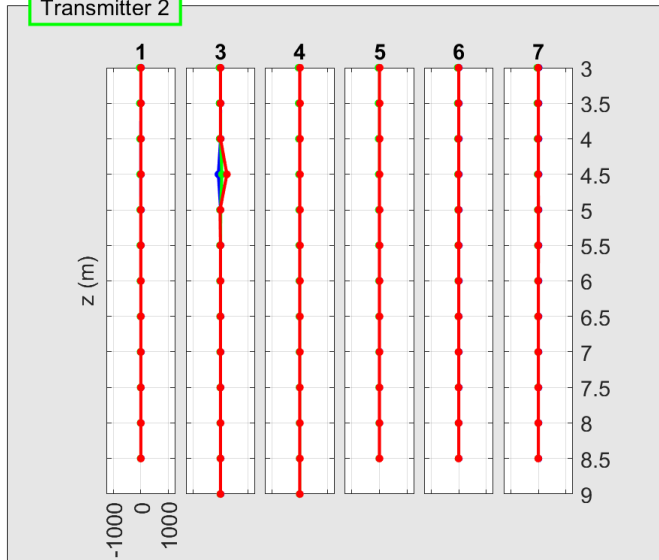
Reference: 100Lb Incendiary (Teltow Item5 Horiz nobg)



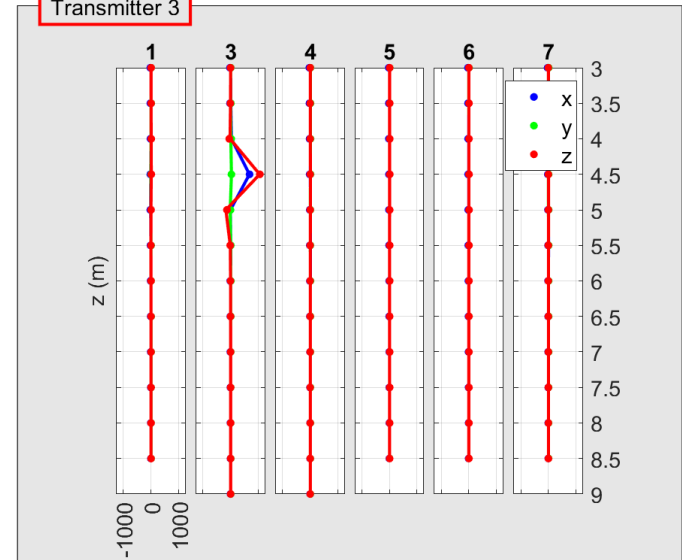
Transmitter 1



Transmitter 2



Transmitter 3



# Target Excavation Challenges & Solutions

04





# Target Execution Infill



Step 1:

- Dredge to 3.0 m
- Removing 1,000 m<sup>3</sup> (1,300 yd<sup>3</sup>) sand-sludge

# Target Execution Infill



## Step 1:

- Dredge to 3.0 m
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## Step 2:

- Fill in canal
- Adding 5,800 m<sup>3</sup> (7,600 yd<sup>3</sup>) sand & gravel mix

# Target Execution Infill



Step 1:

- Dredge to 3.0 m
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Step 2:

- Fill in canal
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Step 3:

- Start excavation
- Pre-drill & Install 15 m sheet pile walls
- Manage water inflow



# Halt Excavation Anomaly 2

- Survey Halted when anomaly 2 moved
- Caused by drilling and pumping water
- Drilling work slowed in order not to reinitialize the so-called "air pump effect"



# Halt Excavation Anomaly 2

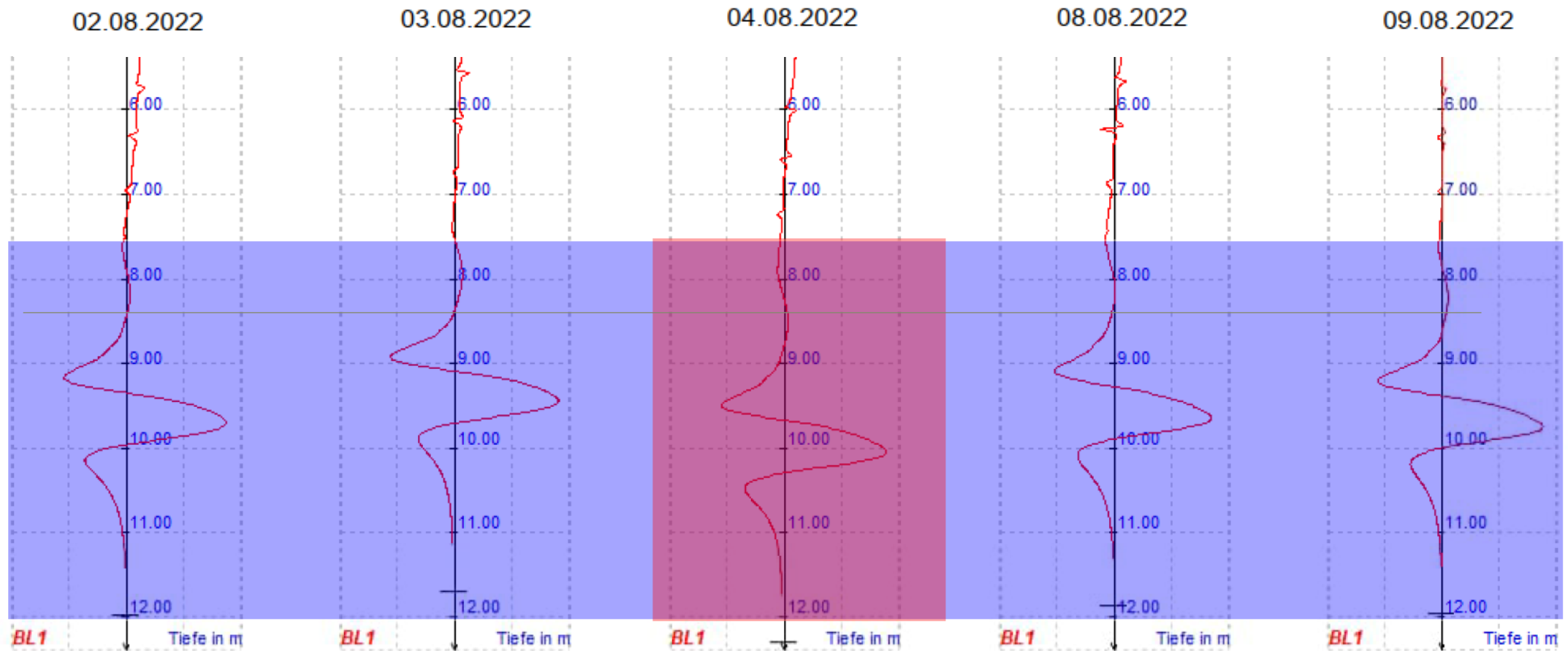
- Survey Halted when anomaly 2 moved
- Caused by drilling and pumping water
- Drilling work slowed in order not to reinitialize the so-called "air pump effect"
- Daily Mag reading taken at start of shift to detect movement
- Dewatering of the holes:
  - Anomaly 1: approx. 250 m<sup>3</sup>/h (66,000 gal/h)
  - Total 360,000 m<sup>3</sup> (95M gal)
  - Anomaly 2: approx. 300m<sup>3</sup>/h (79,000 gal/h)
  - Total 810,000 m<sup>3</sup> (214M gal)



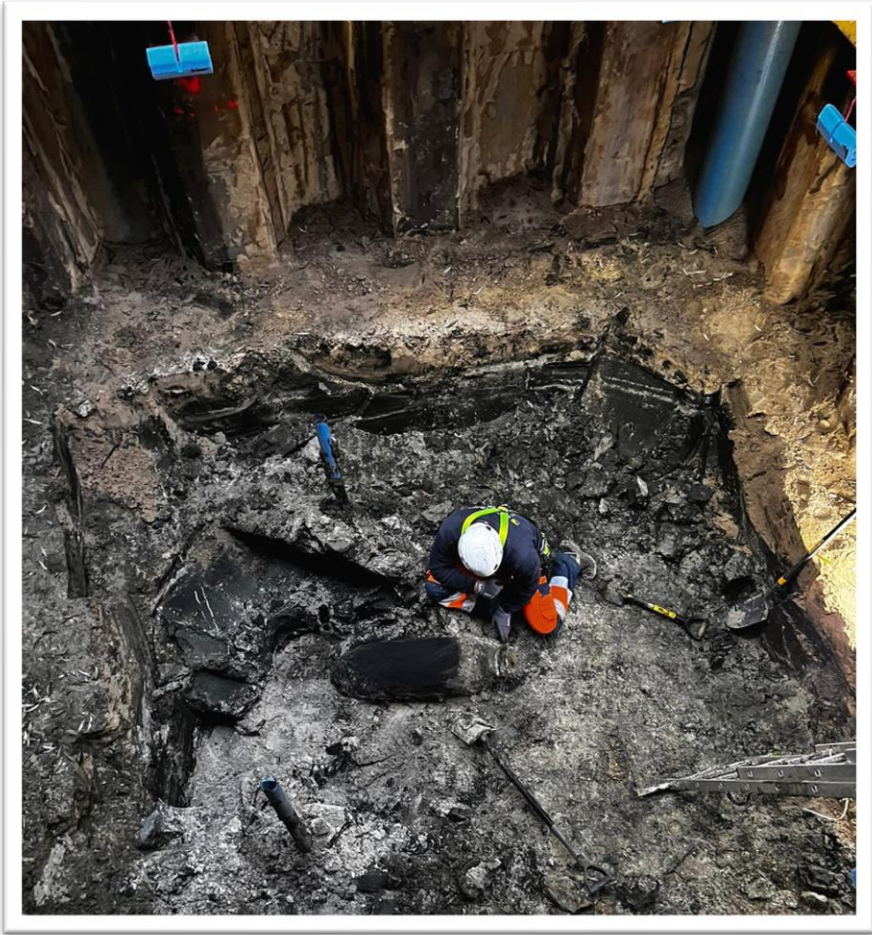
Proof of offset: approx. 50 cm above the actual unexploded ordnance find – clear marking of the bomb in the overlying layer of earth

# Halt Excavation Anomaly 2

Time



# Identification Fuses



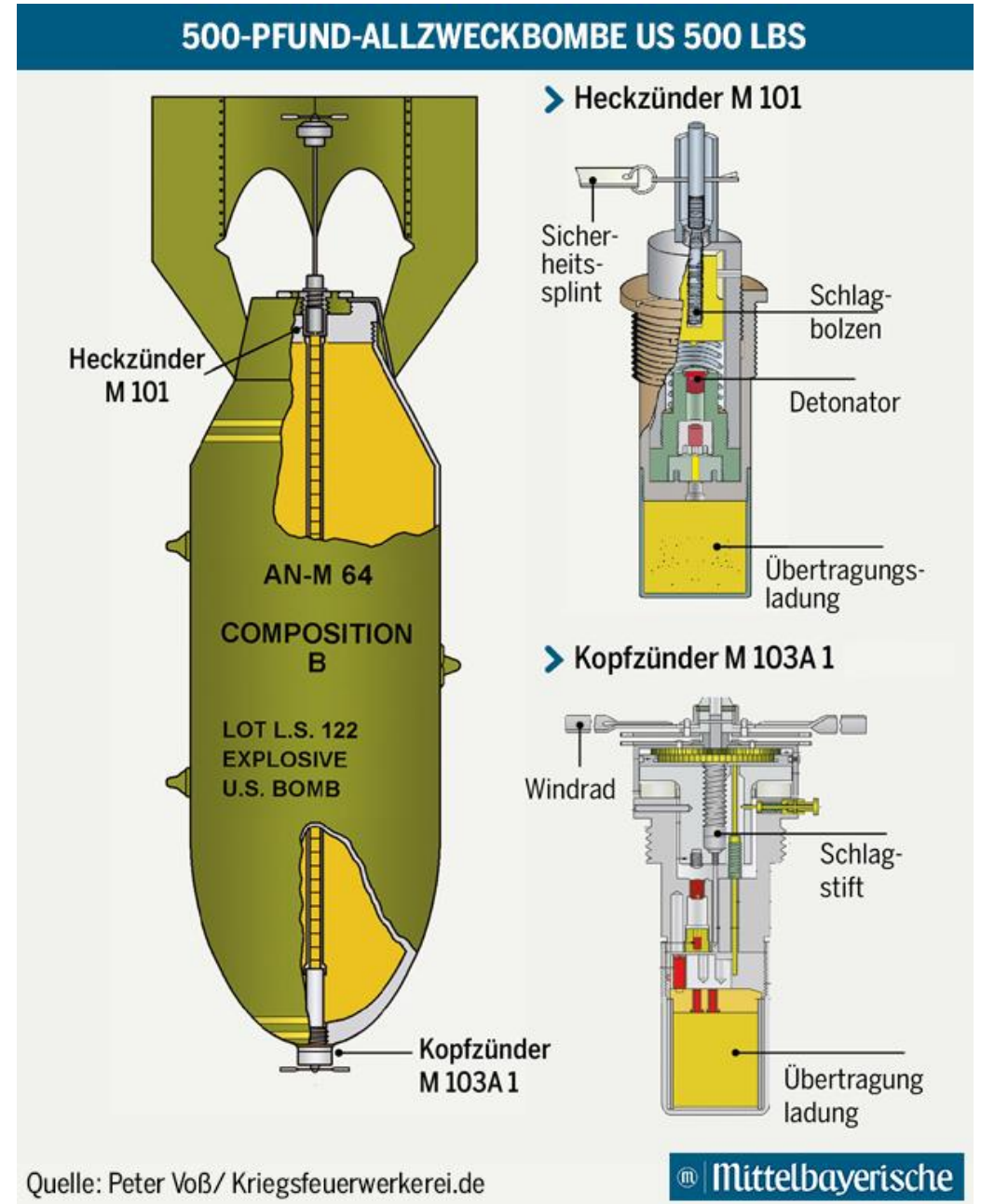


# Identification of anomalies

## Fuses

### Anomaly 1 + 2

- US General Purpose, 500-lb
- Head detonator M103
- Ground detonator M101
- Filling consists of approx. 120Kg TNT or Anatol



# Day of Defusing Evacuate

- Oranienburg, Germany
- 07th Dec, 2022
- Exclusion zone radius 1 km
- 2800 people evacuated



# Questions & Thanks for your attention

Acknowledgements:

Kristina Kaestner, HH KMR

Kristian Kragiel, HH KMR

Laurens Beran, BTG



**Gap EOD**

Gap Explosive Ordnance Detection

