# Advanced UltraTEM-III UXO detection and classification in the South Pacific Region

William Rowlands – *GapEOD, Australia*
Stephen Billings – *GapEOD, Australia*
Remke van Dam – *GapEOD, Brazil*

Gap EOD
Gap Explosive Ordnance Detection

Black Tusk
GEOPHYSICS

UltraTEM-II, PNG

# Presentation Overview

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1 **The Motivation**

Danger posed by buried UXO to civil works.

2 **The Solution - EMI**

Benefits of EMI Methods.

3 **UltraTEM-III Technology**

Our new technology.

4 **Case Study 1**

UXO at RAAF Base Williamtown.

5 **Cast Study 2**

UXO at a Copper Mine in Laos.

6 **Conclusion and Other Applications**

UltraTEM technology in other applications.

# The Motivation - UXO

**Personal Danger**
Risk to people who live and work in areas of UXO contamination.

**Costly**
Remediation process slow with areas needing to be searched at multiple levels.

**Developing Countries**
UXO may lay in-situ for many decades.

**Lack of Records**
Hard to distinguish between high and low risk area.

Japanese Aircraft Bomb, Lae PNG


EM-61, Laos

# TDEM Systems

## PROS

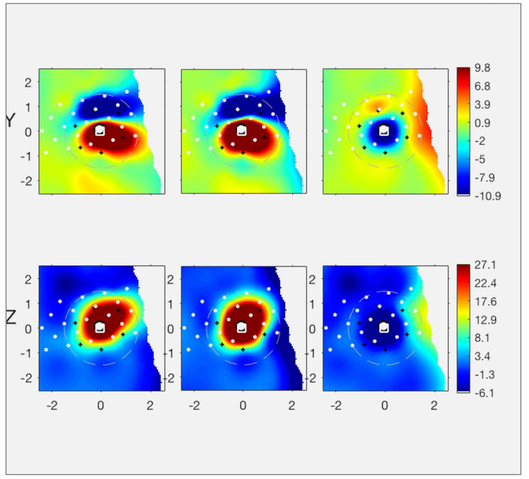
- Popular and proven for UXO Detection
- Digital Auditing
- Can detect non-ferrous objects

## CONS

- Receiver Limitations (target discrimination)
- Transmitter power (detection depth)
- Non-flexible form factor

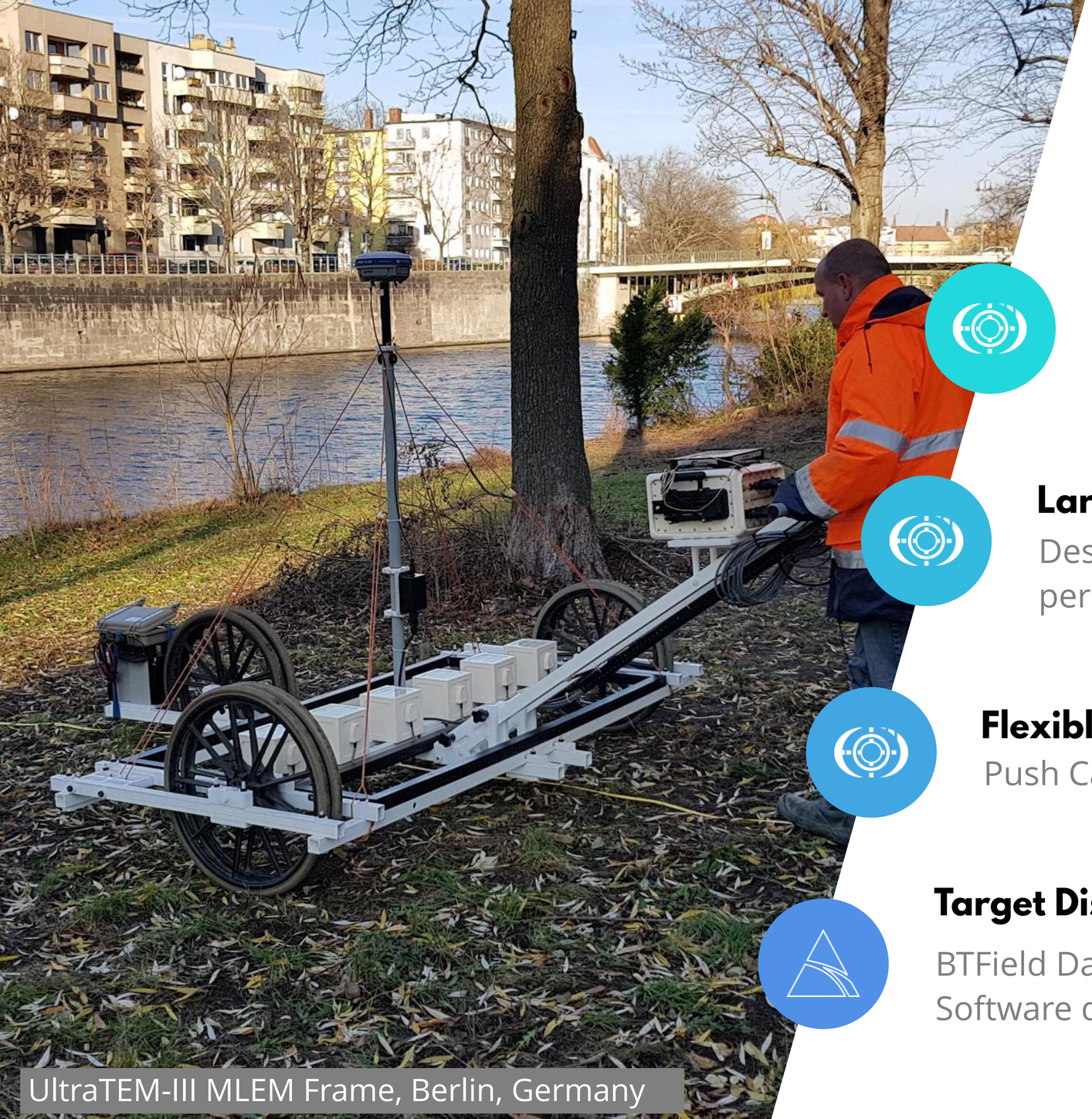
# UltraTEM-III

**Powerful EM Transmitter** → **Multi 3-comp Rx Modules** → **Flexible Form Factor** → **Custom Software**

# High Resolution

## MLEM Operation



UltraTEM-III MLEM Frame, Berlin, Germany

### MLEM Configuration

Transmitter coil is co-located with sensors on moving non-metallic frame.

### Large Area Coverage

Designed to coverage areas over 1 ha/day. 1-2 person operation. Suited to Cluttered urban areas.

### Flexible Form Factor

Push Cart, Man-carried, or towed array.

### Target Discrimination

BTField Data Acquisition and Processing Software designed by Black Tusk Geophysics.

# Deep Search Mode

## FLEM Operation

UltraTEM-II FLEM Frame, Pakse, Laos

### FLEM Configuration

Transmitter coil is separated from the sensors. High Power Tx Current.

### Large Area Coverage

Designed to coverage areas over 1 ha/day. 2-3 person operation. Suited to open areas.

### Flexible Form Factor

Push Cart, Man-carried, or towed array.

### Target Discrimination

BTField Data Acquisition and Processing Software designed by Black Tusk Geophysics.

# Data Sheet Extract

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UltraTEM-II, PNG

| | |
|---|---|
| Coil Area | 3.78 $m^2$ |
| Analogue Digital Converter | 23 bit + 1 sign bit |
| System Noise @ 1000 Hz | < 4 nT/√Hz |
| Receiver Sampling Frequency | 800 kHz |
| Number of Stacks | 8 |
| Stacking Method | Weighted, overlapped |
| Output Decays | 8 per second |
| Samples per Decay | 45 samples evenly spread over logarithmic time scale |
| Decay Length | 0.9 to 10 ms |
| Supply Voltage | 9 to 15 V |
| Current draw (6 coils, FG, IMU) | 2.8 A at 13 V |
| Power requirement | 36.4 W |

# Case Study 1

## RAAF Base Williamtown

# Project - Overview

### Base Operated late 1930's to Present

American and British troops on base during WWII.

### Royal Australian Air Force

$679 m AUD Redevelopment of Base

R8000 New Air Combat Capability (NACC) Facilities Project.

**Project Location: RAAF Base Williamtown.**

# Detection Requirements

### 20mm HEI projectile @ 300mm (1’)

Assumed detectable metal 100 g (3.5 oz.).

### 8.5lb Practice Bomb @ 1500mm (5’)

Assumed detectable metal 1.0 kg (35 oz.).

### Locate Large Obstructions

Any items that may pose an issue to earthworks

30 mm Chain link from burn pit. Australia

UltraTEM Prototype Towed Array. Australia

# Survey Method

## MLEM Operation

### TOWED ARRAY

- 8 sensors, 30 cm spaced
- 2.6 m swath
- 2.6 x 1.0 m Tx loop
- Daily Coverage of 4 ha (10 ac.)

### PUSH CART

- 6 sensors, 30 cm spaced
- 1.8 m swath
- 1.8 x 0.9 m Tx loop
- Daily Coverage of 1 ha (2.5 ac.)

# Survey Area

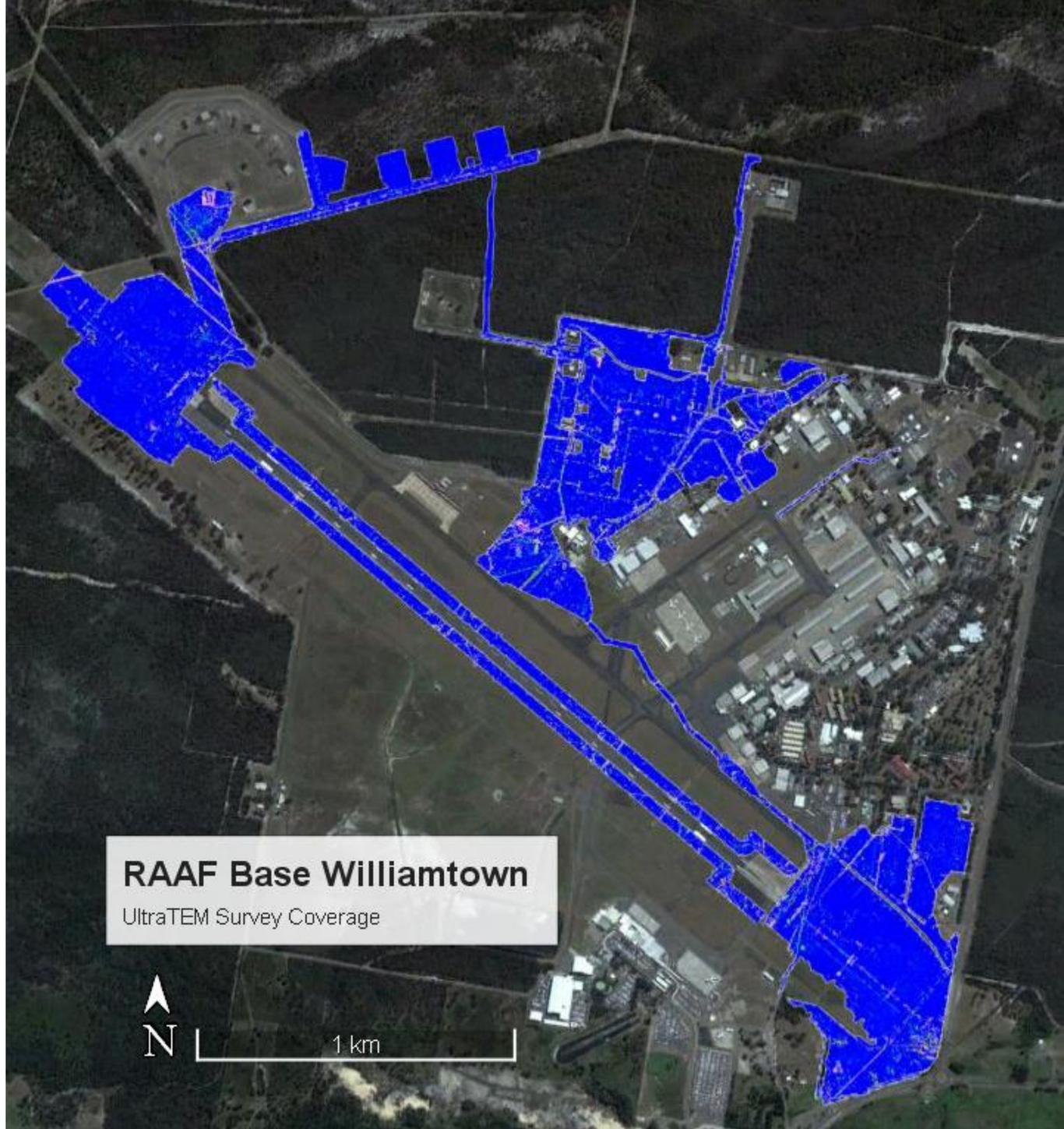
Ongoing

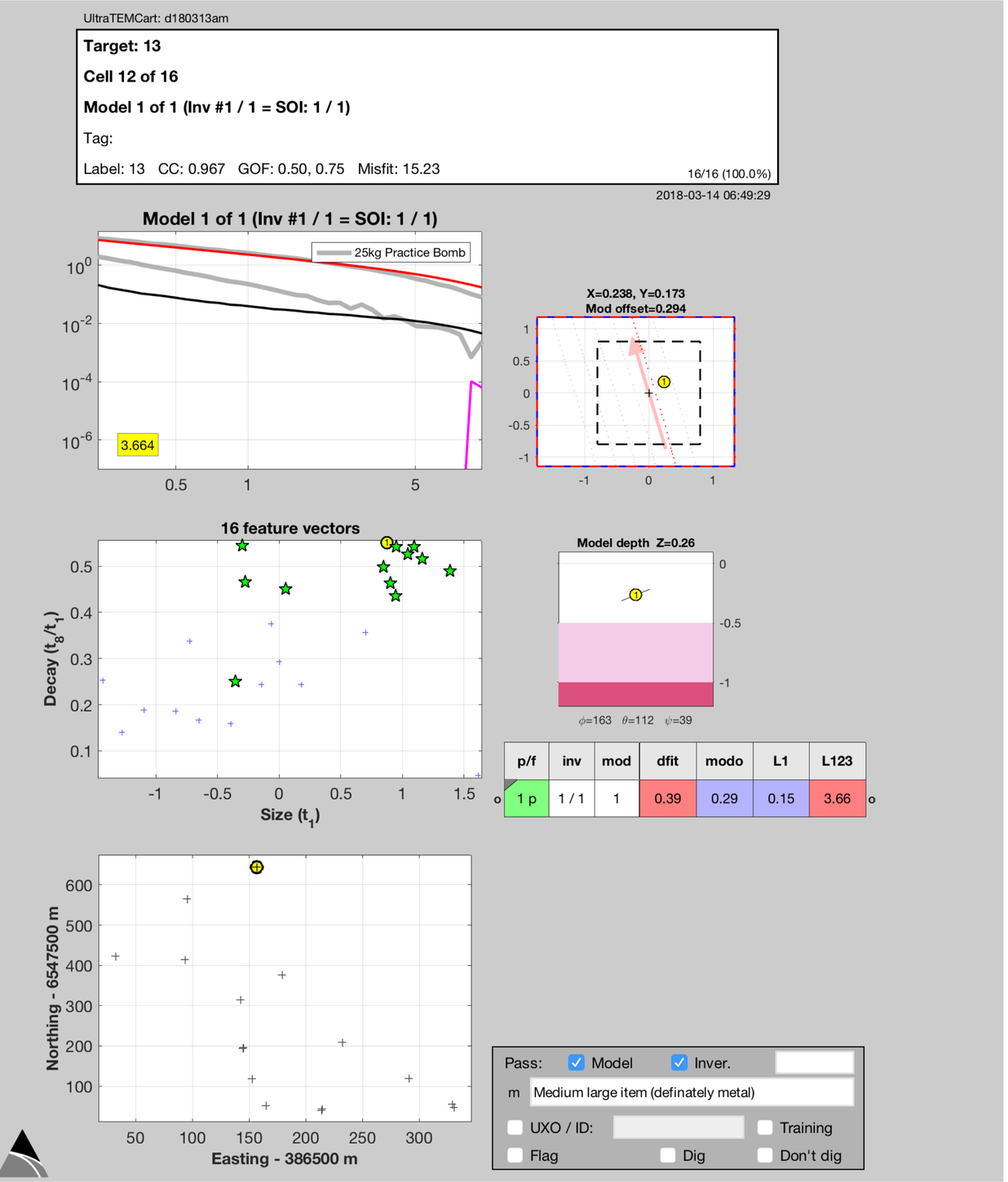
2015 ▶ 120 ha (300 ac)

2016 ▶ 1.2 ha (3.0 ac)

2017 ▶ 1.4 ha (3.5 ac)

2018 ▶ 2.0 ha (5.0 ac) planned

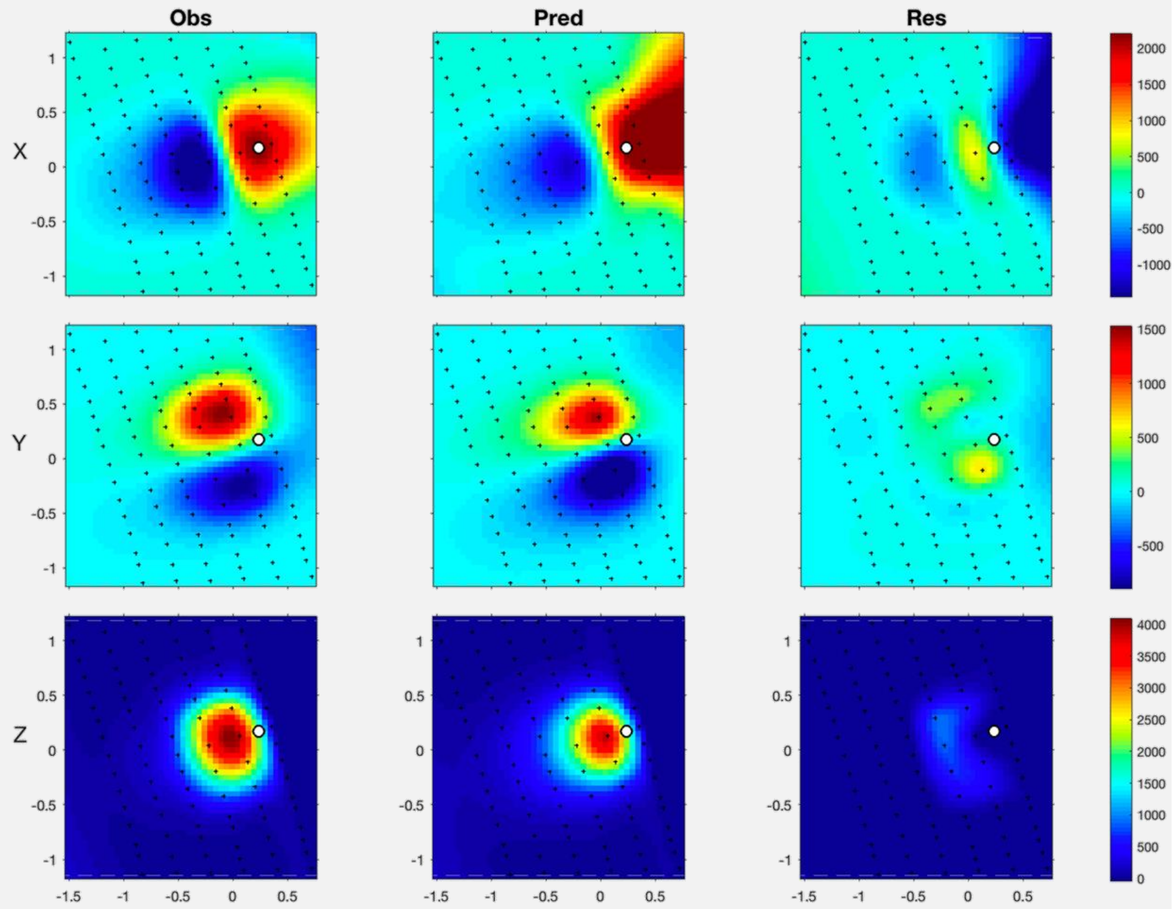


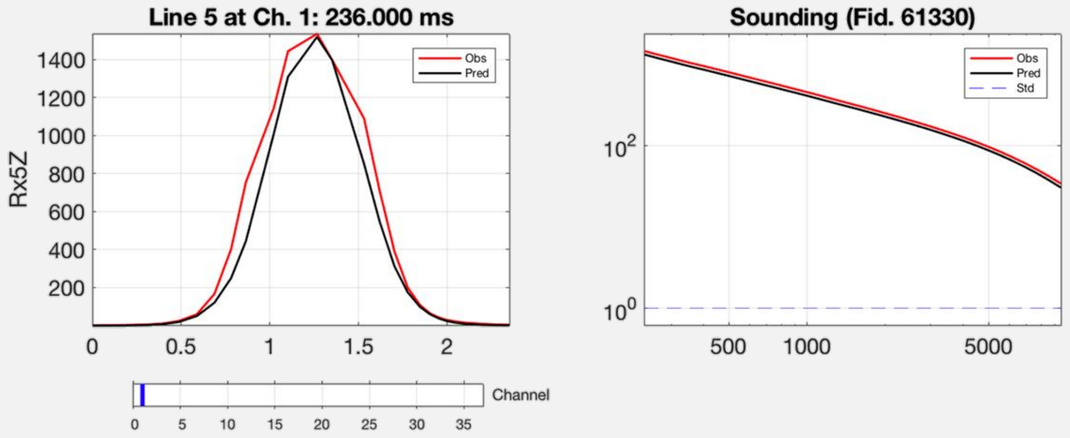



# Processing and Interpretation

## Processing

- Rx values normalised to Tx current
- Background and Geological feature removal




# Processing and Interpretation

## Processing

- Rx values normalised to Tx current
- Background and Geological feature removal

## Interpretation

- Early time anomalies of 5 uV selected for  further interpretation
- Anomalies with characteristic metal decay added to dig list

# Results

1918 Howitzer 6”

30 mm rounds recovered from burn pit. Australia

## Targets

- >10,000 anomalies identified

## Ground Truth

- 20 mm and 30 mm rounds
- 50 Calibre
- Primers
- 30 mm chain link
- WWI 1918 Howitzer (6”)

# Case Study 2

## UXO at a Copper Mine in Laos

# Project Overview

### Sepon (MMG Limited)

Open-pit copper mine in Southern Laos.

### Heavily Bombed during Vietnam War

Project straddles the Ho Chi Minh Trail

Project Location: Sepon, Laos

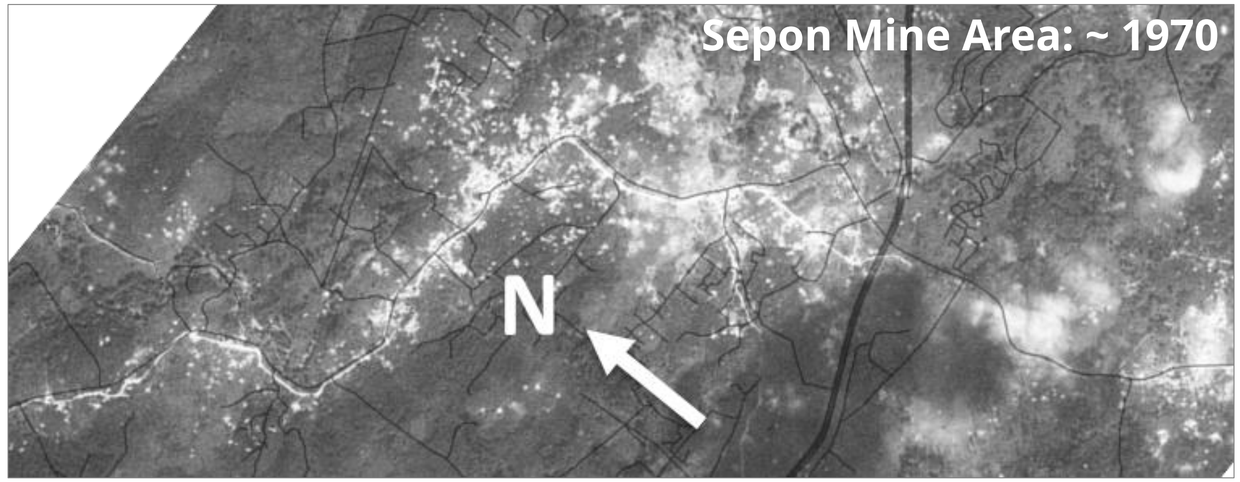
# Project Overview

## UXO

Up to 20 % of the many millions of aircraft bombs did not explode.

## Deeply Buried

UXO can be buried deep due to the steep terrain. Large effect on daily mining operations.

# Items of Concern

### Aircraft Bombs

MK81: 250 lb bombs

MK82: 500 lb bombs

Sepon Mine, Laos

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### Clearance

Up to 3.0 m to be efficient

Sepon Mine, Laos

# Items of Concern

### Aircraft Bombs

MK81: 250 lb bombs

MK82: 500 lb bombs

### Clearance

Up to 3.0 m to be efficient

### Magnetic Geology

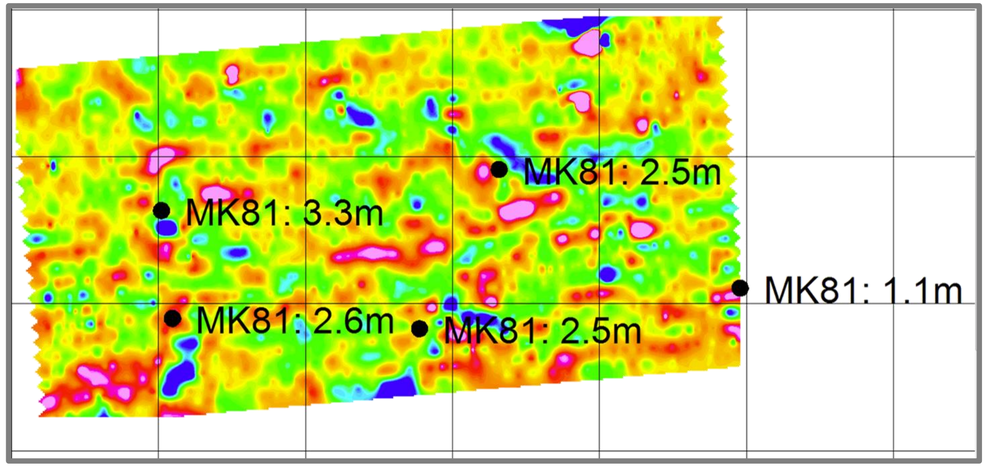
Causes additional detection problems

Sepon Mine, Laos

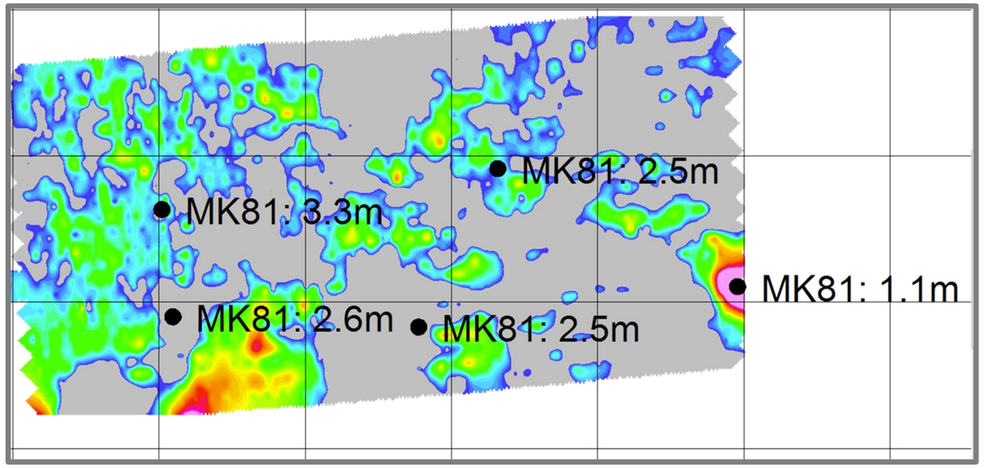
# Blind Trials

2014

## Magnetometer




## EM61 towed-array



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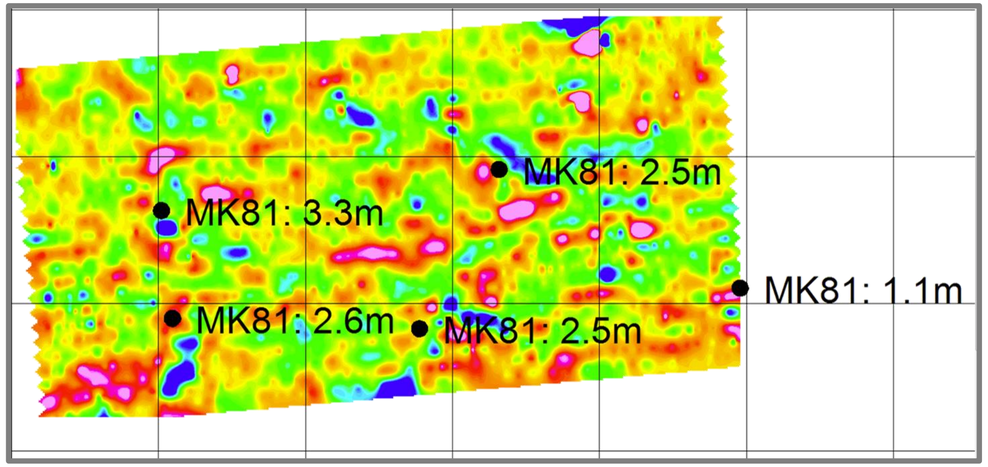


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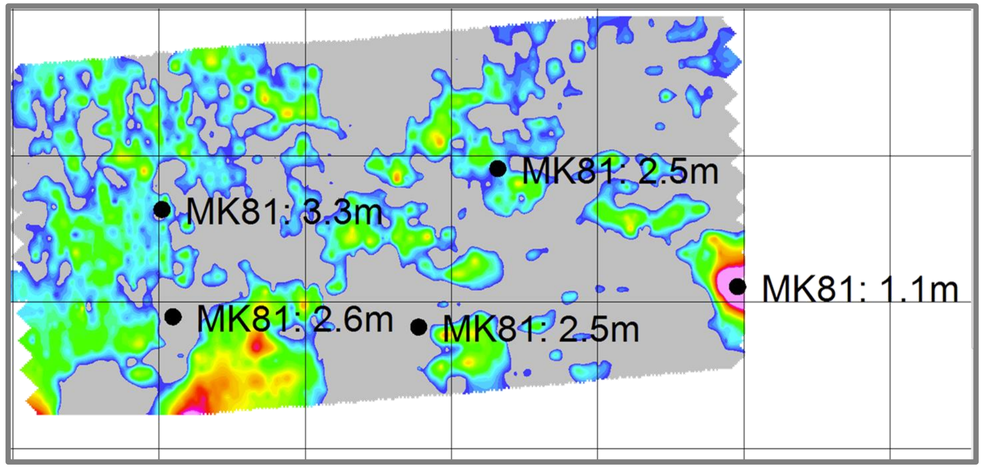
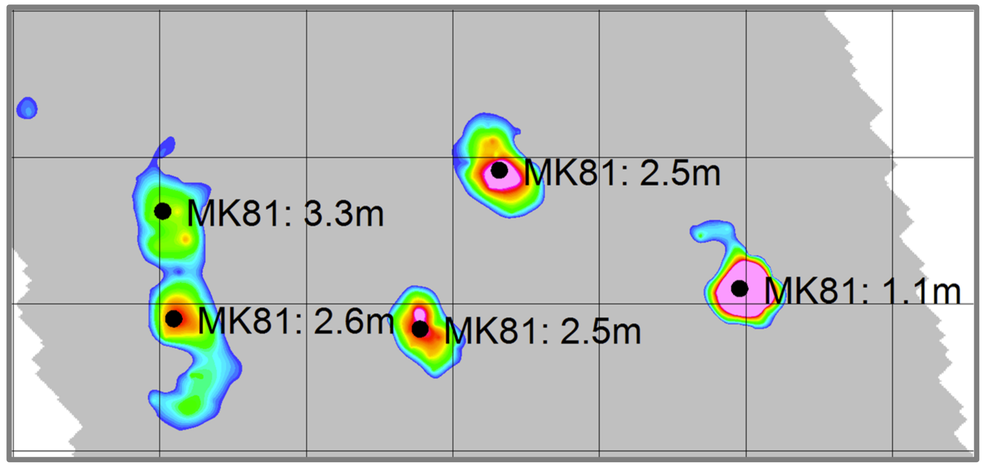


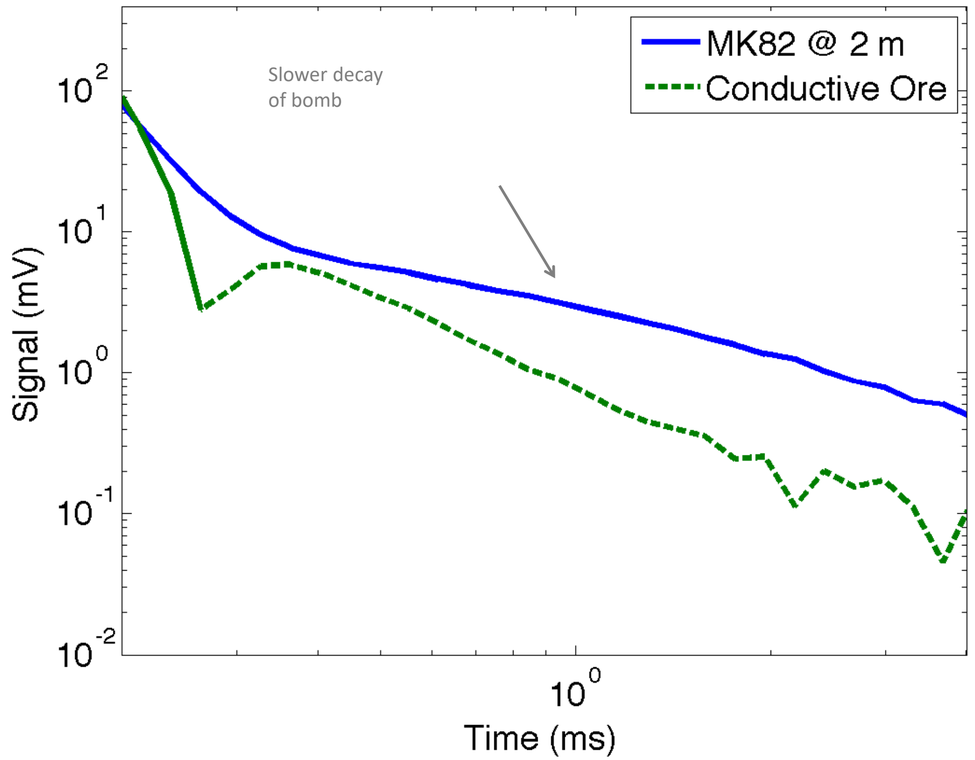

## UltraTEM FLEM Configuration



| Item | Depth | Orientation | Detected | Soil conditions |
|---|---|---|---|---|
| MK82 | 1.8 m | horizontal | Yes | High-mag |
| MK82 | 2 m | horizontal | Yes | High-mag |
| MK82 | 3 m | vertical | Yes | High-mag |
| MK81 | 3 m | vertical | Yes | High-mag |
| MK82 | 3 m | 45 degrees | Yes | High-mag |
| MK82 | 3 m | vertical | Yes | High-mag |
| MK81 | 3 m | horizontal | Yes | High-mag |
| MK81 | 3 m | horizontal | Yes | High-mag |
| MK82 | 3 m | vertical | Yes | High-mag |
| MK82 | 3.5 m | horizontal | Yes | High-mag |
| MK81 | 3.5 m | horizontal | Yes | High-mag |
| MK82 | 3.5 m | vertical | Yes | High-mag |
| MK81 | 3.5 m | vertical | Yes | High-mag |
| MK81 | 3.5 m | horizontal | Yes | High-mag |
| MK82 | 3.75 m | horizontal | Yes | High-mag |
| MK81 | 4.25 m | vertical? | Yes | Low-mag |
| MK82 | 4.5 m | horizontal | Yes | High-mag |
| MK81 | 5.25 m | horizontal | Yes | Low-mag |
| MK81 | 5.25 m | vertical | Yes | Low-mag |
| MK82 | 5.25 m | vertical | No | High-mag |
| MK81 | 5.25 m | horizontal | No | High-mag |

# Detection and Discrimination

The UltraTEM system consistently detected all bombs to depths of 5 m.



# Implementation

### Deployment

UltraTEM-II system deployed in March 2015.

**Daily Use** by MMG

### FLEM Deep Search Configuration

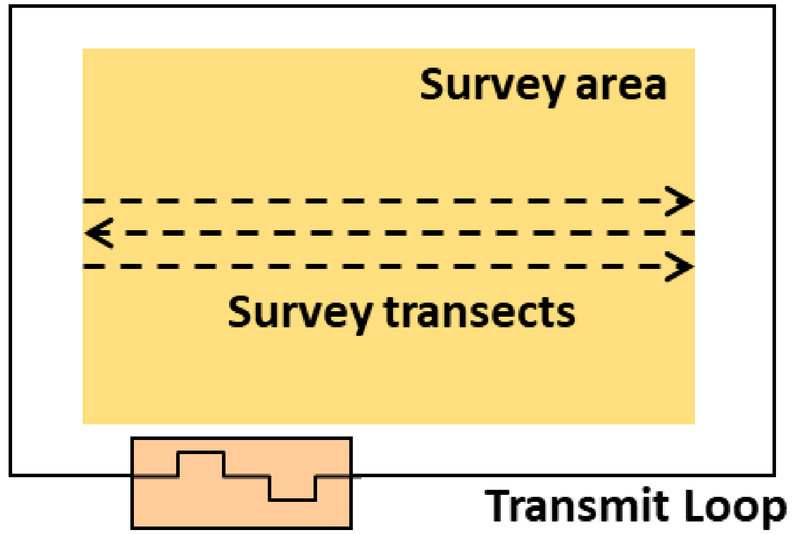
Array Swath 4 m wide. Daily coverage up to 1.2 ha.

### Onsite Geophysicists

Data processing on-site. Targets dug within 2 hours of data transfer

### Target Discrimination

**Since UltraTEM implementation no UXO have been missed**

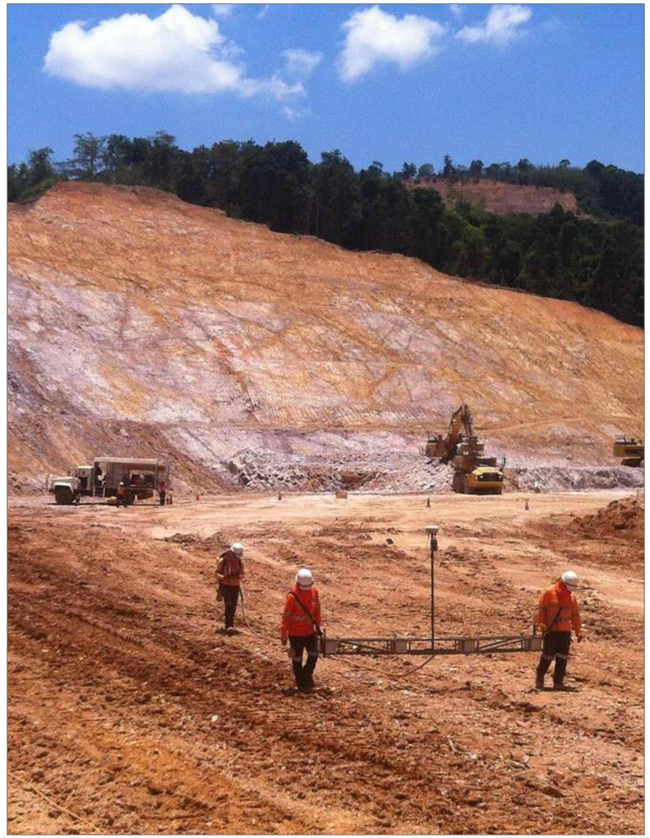




Local field crew trained on-site

# Implementation

Sepon MMG

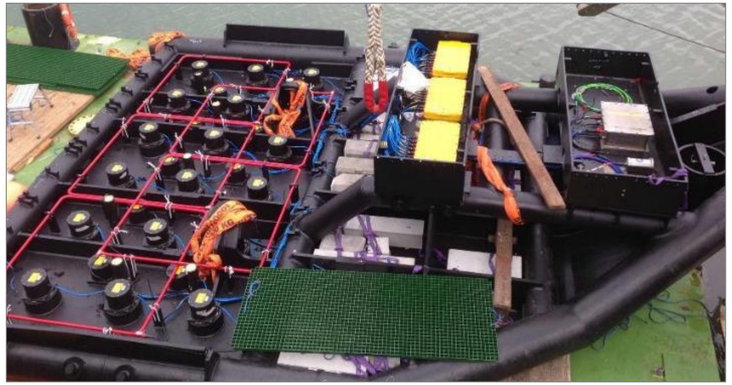


In-pit Survey

Vegetation Clearance

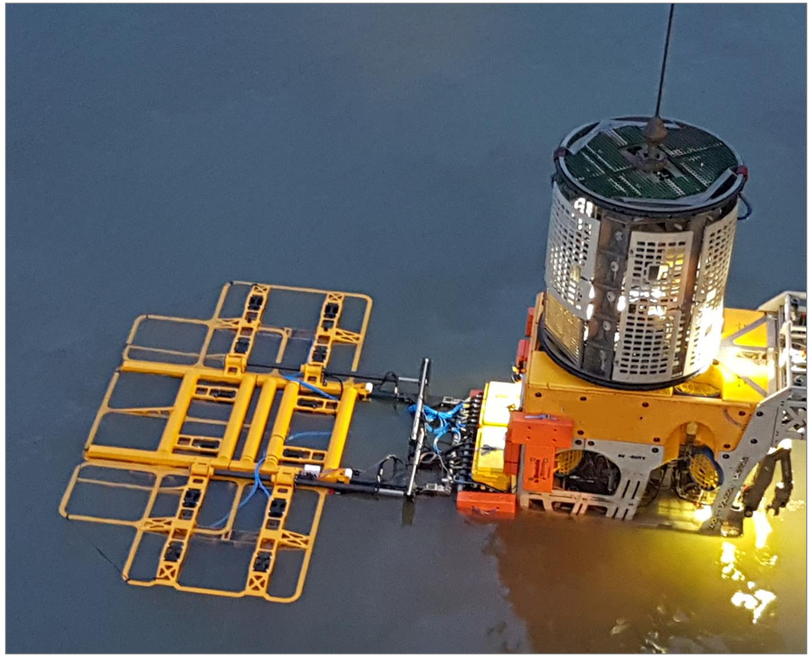
Heavy Vehicle Interaction

# Other Applications



UltraTEM-Marine Sledge

Ground Engaging Tools (GET)



UltraTEM-Marine ROV

# Conclusions

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## Accuracy

The UltraTEM is a geophysical technology that allows for metal object searches with high fidelity.

## Dependable

The powerful transmitter and three-component EM receivers produce high data clarity allowing for dependable discrimination of objects.

## Proven

The presented case studies show the successful implementation of this technology in operational challenging civil and mining  conditions.

## Customizable

The flexible form factor and ability to customize the Tx and Rx array makes the UltraTEM a solution to a range of metal detecting scenarios.

# Thanks for your attention

# Questions

Will Rowlands <wrowlands@gapeod.com>
Stephen Billings <stephenbillings@gapeod.com>

Partners and Contributors

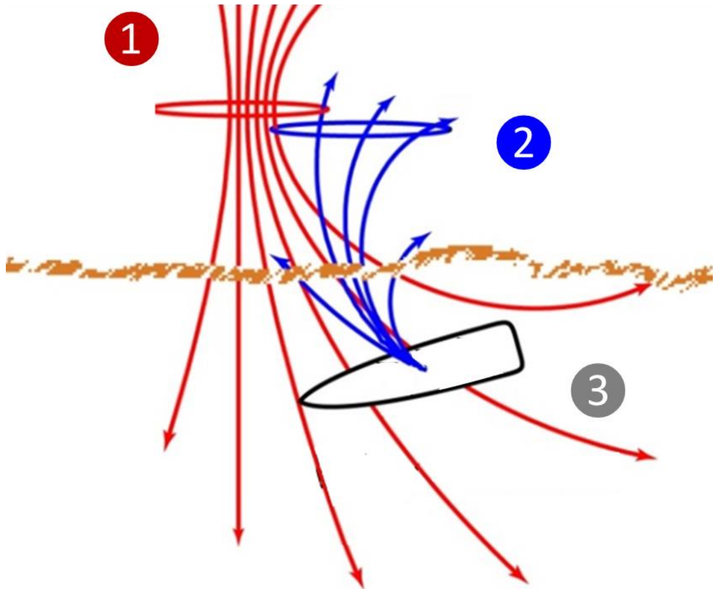
OPEC SYSTEMS

MMG

Black Tusk GEOPHYSICS

Gap EOD
Gap Explosive Ordnance Detection

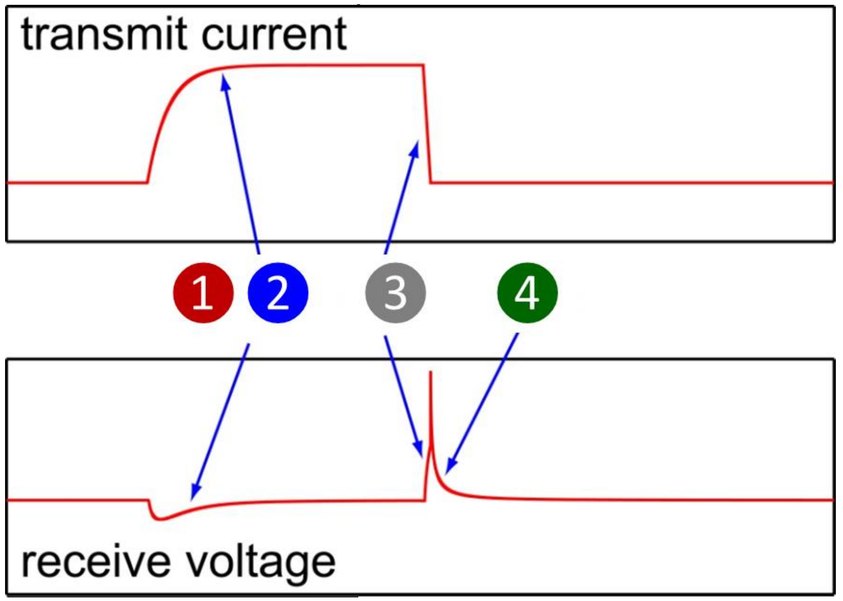
# The Solution – EMI for Metal Detection




**Electromagnetic Induction (EMI):**

1. Primary Field from a Transmit Loop induces electrical currents in a buried object.
2. The Induced Field is *measured* in a Receiver Loop.

**→ Detection of objects**




**Time-domain EM (TDEM):**

3. An abrupt change in primary field *excites Eddy Currents* in the object.
4. Eddy currents diffuse throughout the object and *decay with time*.

**→ Characterization of objects**