



# UltraTEM GET Technical Memorandum

## 1. Introduction

Gap Explosive Ordnance Detection Pty Ltd (GapEOD) is an Australian company that specialises in the detection and characterisation of near-surface metallic items both on land and underwater. GapEOD's goal is to provide clients with high-quality, cost effective digital geophysical data with superior performance to conventional instruments and techniques. Our services are based on innovative technologies that have proven their success in a range of conditions.

GapEOD have developed the multi-component multi-sensor UltraTEM system, which allows for ultra-high-definition digital mapping with high efficiency. The UltraTEM system can distinguish closely spaced individual targets, provides accurate estimates of object position and depth, and produces auditable digital recording of all data. Use of GapEOD's high-power transmitters enables the system to achieve greater imaging depths and to work effectively in areas of magnetic geology that render passive magnetometers and standard EM equipment unusable.

The UltraTEM system can be deployed in two different primary configurations: (i) Moving Loop that focuses on rapid and efficient large-area searches (Figure 1); (ii) Fixed Loop for Ultra-Deep investigations of deep targets and for operation in geologically hostile terrain. The UltraTEM system has proven its unique capabilities in production surveys for large-area UXO detection, deep bomb detection and detection of Ground Engaging Tools (GET) in mine stockpiles.



FIGURE 1. ULTRATEM MOVING LOOP TOWED-ARRAY.

## 2. System Components

### 2.1. Summary

The components and geometry of the UltraTEM are not fixed and can be optimised for the detection problem being addressed. All UltraTEM system components are synchronized with the 1PPS signal from GPS receivers which allows precise time-alignment of all data streams. An UltraTEM system is assembled using the following base components:

- i. UltraTEM-IV Receiver Bank containing six receiver cards.
- ii. Multiple 3-component receiver cubes (up to six per UltraTEM-IV receiver bank). Receiver cubes consist of three orthogonal coils with dimensions of 15 cm x 15 cm x 15 cm each with an effective area of 104.5 m<sup>2</sup>.
- iii. High current geophysical transmitter. Either the EODTx 50 Amp system, or the high-powered EODTx 200 Amp transmitter.
- iv. A Real-Time-Kinematic Global Positioning System (RTK-GPS) for accurate tracking of the position of the receiver system.
- v. An Attitude Heading and Reference System (AHRS) for position and orientation of the sensor frame.
- vi. A data acquisition system running BTField software developed by Black Tusk Geophysics.

### 2.1. Data Analysis

UltraTEM processing and interpretation are performed using Black Tusk Geophysics' UXOLab software package. UXOLab has several tools for manipulation and quality control of both the raw sensor, GPS and AHRS data and the merged datasets used for mapping and characterization. All processing steps are tracked so that the processing flow can be audited at a future point. After automated or manual selection of anomalous regions in a survey area (Figure 2), inversion of a physics-based model of the data is used to make dig or no-dig decisions (Figure 3). Dig or no-dig decisions can be made using a wide variety of criteria dictated by project requirements. For instance, all items that exceed a certain size could be excavated, or only those objects displaying characteristics of UXO (axial symmetry), or only those items within a user specified depth range.

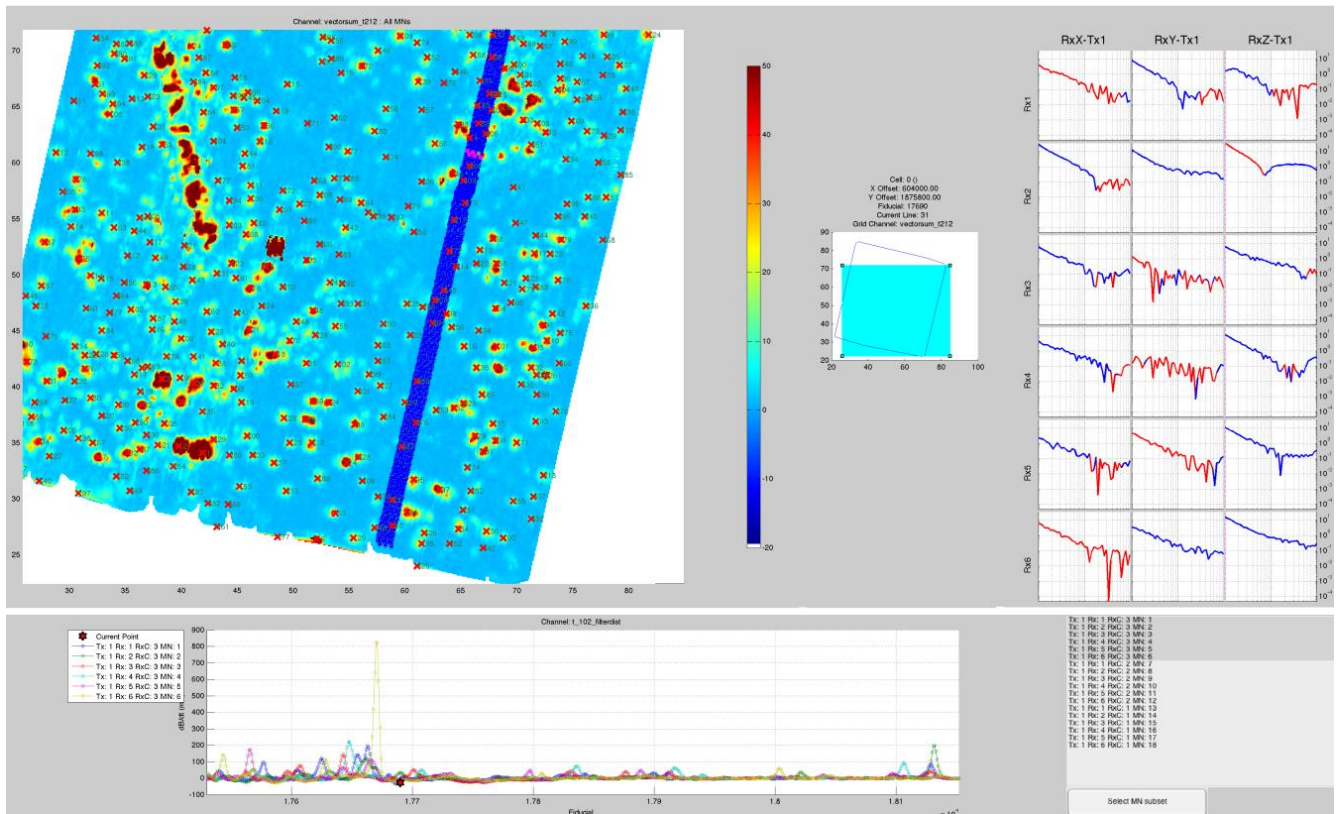


FIGURE 2: ONE OF THE INTERFACES IN THE UXOLAB SOFTWARE USED FOR DATA ANALYSIS AND INTERPRETATION.

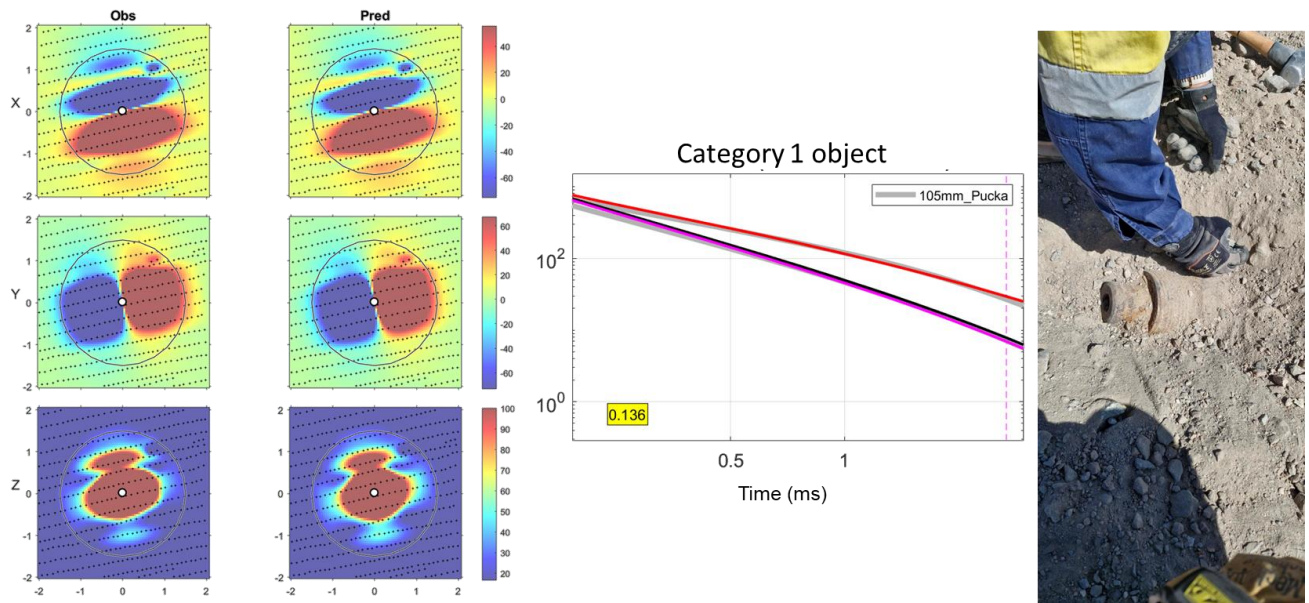


FIGURE 3. UXOLAB INVERSION REVIEW INTERFACE. THE OBJECT MODELLED HERE DISPLAYS AXIAL SYMMETRY (HENCE HAS A UXO-LIKE SHAPE), IS SIMILAR IN SIZE TO A 105 MM PROJECTILE AND TARGET GROUND TRUTH REVEALED A LARGE DRILL BIT.

### 3. UltraTEM Configurations

#### 3.1. UltraTEM Moving Loop

In UltraTEM Moving Loop mode, the transmitter coil is co-located with the sensors on a light-weight platform. This mobile configuration is ideal to achieve quick coverage of large areas, either by foot or using an UTV (Figure 4). The UltraTEM Moving Loop system utilising high-current EODTx50 transmitter connected to a small transmitter loop mounted to the system.

The UltraTEM Moving Loop towed-array system has been deployed numerous times at Newmont Boddington Gold Mine in WA and Lake Cowal Gold Mine in NSW to detect GET in ore stockpiles. Depending on the size of the GET items present, the clearance depth for this system at Boddington and Lake Cowal is between 2.5 and 3.0 m. The towed and pedestrian systems can survey approximately 2 Ha and 1 Ha per survey day respectively. Production rates can be improved if the survey area is smoothed into a large flat surface with no internal windrows or benches. Detection depths for GET items is dependent on the size of the items of interest and geophysical background response of the ore stockpile.



FIGURE 4. ULTRATEM MOVING LOOP FORM-FACTORS.

### 3.2. UltraTEM Fixed Loop

The UltraTEM Fixed Loop configuration is deployed when deep metal detection is the overriding priority. In this configuration a large loop of copper wire is laid around the survey area and the field crew survey inside the wire loop using an UltraTEM-IV receiver system. The loop configuration can be dictated by terrain and space limitations of the survey area within certain constraints imposed by the desired detection depth. Loops are typically 14 x 100 meters but can be as small as 10 x 10 metres.

The transmitter for the system consists of a GapEOD EODTx200 fast-switching transmitter running off a GapEOD PS10LV power supply powered by a diesel three-phase generator (Figure 5). Use of the PS10LV and off the shelf three-phase generator has been used extensively at active mine-sites where health and safety regulations prohibit the use of petrol generators.

This system can transmit up to 200 A with a maximum output of less than 120 V. The EODTx200 has an inbuilt timing controller and can transmit at a range of base-frequency and duty cycles to suit survey requirements. It is precisely synchronized to the 1PPS signal from a GPS timing card.



FIGURE 5. FIXED LOOP TRANSMITTER AND GENERATOR CONFIGURATION.

At the Citic Pacific's Cape Preston magnetite mine, GapEOD uses the UltraTEM system to detect GET that are lost in a magnetite stockpile to depths of at least 3.0 m for small-medium GET and deeper for large GET (Figure 6). These surveys are done with the UltraTEM fixed-loop system and a push-cart receiver system. The system has been used to scan eleven different layers of the stockpile for a total scan area of 68 Ha. With a 3 m scan depth this translates to a volume of 2 million cubic meters of ore material scanned. In the process, over 60 pieces of GET have been recovered from the stockpile with no GET making it through to the crusher in the process. Detection depths for GET items is dependent on the size of the items of interest and geophysical background response of the ore stockpile. A survey trial is the best way to establish the detection thresholds for a specific site.



FIGURE 6. SOME OF THE PIECES OF GET RECOVERED IN A MAGNETITE STOCKPILE IN WESTERN AUSTRALIA.

### 3.3. Conclusion

Key benefits of the UltraTEM are that:

- i. The system is largely immune to ferromagnetic minerals in soils and rocks that can render magnetometers virtually unusable;
- ii. It has a much higher spatial resolution and more concentrated response than competing technologies, allowing individual items to be distinguished in cluttered areas and detection performance to be maintained in proximity to cultural features;
- iii. It can detect both ferrous and non-ferrous items;
- iv. It collects a much richer set of data including the full three-dimensional EMI field over a wide time-range, which results in much more accurate localization and characterization of the size, shape and wall-thickness of buried items; and
- v. Dig decisions are based on objective criteria and all stages of the decision-making process are supported by a digital audit trail.