Gradiometers for UXO Detection

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GSE Rentals

Traditional Detection Methods….

- Pulse Induced Metal Detector

- Towed Magnetometer

Pulse Induction Sensors

Pro's

- Will detect any conducting metal

Con's

- Very Short Range (perhaps 2-3m)
- Poor Sensitivity (around 1 nT)
- Slow update rate (2 second cycle time)

Magnetometers

Pro's

- Higher sensitivity (theoretically 0.02nT)
- Faster cycle rates (Up to 10Hz)
- Longer range detection

Magnetometers

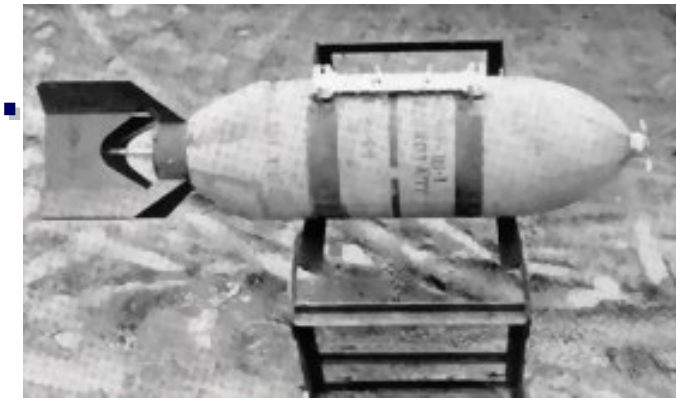
Con's

- Large distant targets mask small local targets.
- Difficult to pick out small target due to background noise.
- No sense of direction of target on single pass.
- Subject to diurnal variations in the earth's magnetic field.

UXO….the targets… what are we looking for?

- **Large WW11 Sea Mine**
- Perhaps 500kg of ferrous material
- Relatively large target
- Range which gives a 1 nT deflection <31m
- Range which gives a 5 nT deflection <18m

UXO….the targets… what are we looking for?



- **250kg HE Bomb**
  - Perhaps 120kg of ferrous material
  - Relatively large target
  - Range which gives a 1 nT deflection <19.5m
  - Range which gives a 5 nT deflection <11.5m

UXO….the targets… what are we looking for?

- **Hand Grenade**

- Perhaps 400g of ferrous material
- very small target
- At 1 nT deflection the range is only 2.9m
- Range which gives a 5 nT deflection <1.7m

(Note at 4 kts you travel at 2m/sec therefore a high update rate is desired for small munitions detection)

Current Technology Available

- Higher sensitivity magnetometer sensors
- Low noise digital transmission.
- Tow platforms such as the Focus that allow fixed height and accurate line spacing.
- 3D software modelling tools such as Geosoft Oasis montaj.
- Towed Gradiometer Platforms.

Description of a Towed Gradiometer

- Two or more synchronised high sensitivity sensors arranged in a fixed geometry array.
- This array can be configured to act in a transverse, vertical, longitudinal manner or a combination of the above.
- The gradient value is derived by comparing the field values from the relevant sensors.

Different Gradients

- Vertical Gradient – One sensor mounted above the other to enhance detection of objects directly below.
- Transverse Gradient – Sensors mounted side by side. Enhances detection to either side of the array.
- Longitudinal Gradient – One sensor behind the other. Enables a long baseline between the sensors (perhaps 20m+).
- Total Field Gradient – A gradient derived from summation of the above.

Advantages of using a Gradiometer

- Distant large targets are ignored.
- Diurnal variations are irrelevant.
- It is possible to “focus” the direction of maximum sensitivity.
- External Noise is automatically filtered when the gradients are calculated.
- By this noise reduction the effective sensitivity is increased.

That was the theory, in practice however we need to consider the following

- Attitude of the array must remain stable.
- A rigid frame must resist vibration.
- As far as practical keep a fixed altitude.
- Individual sensors may give slight linear offsets from one another.
- Frame gives high drag which makes deep towing tricky.

Marine Magnetics Corporation
SeaQuest Gradiometer Platform

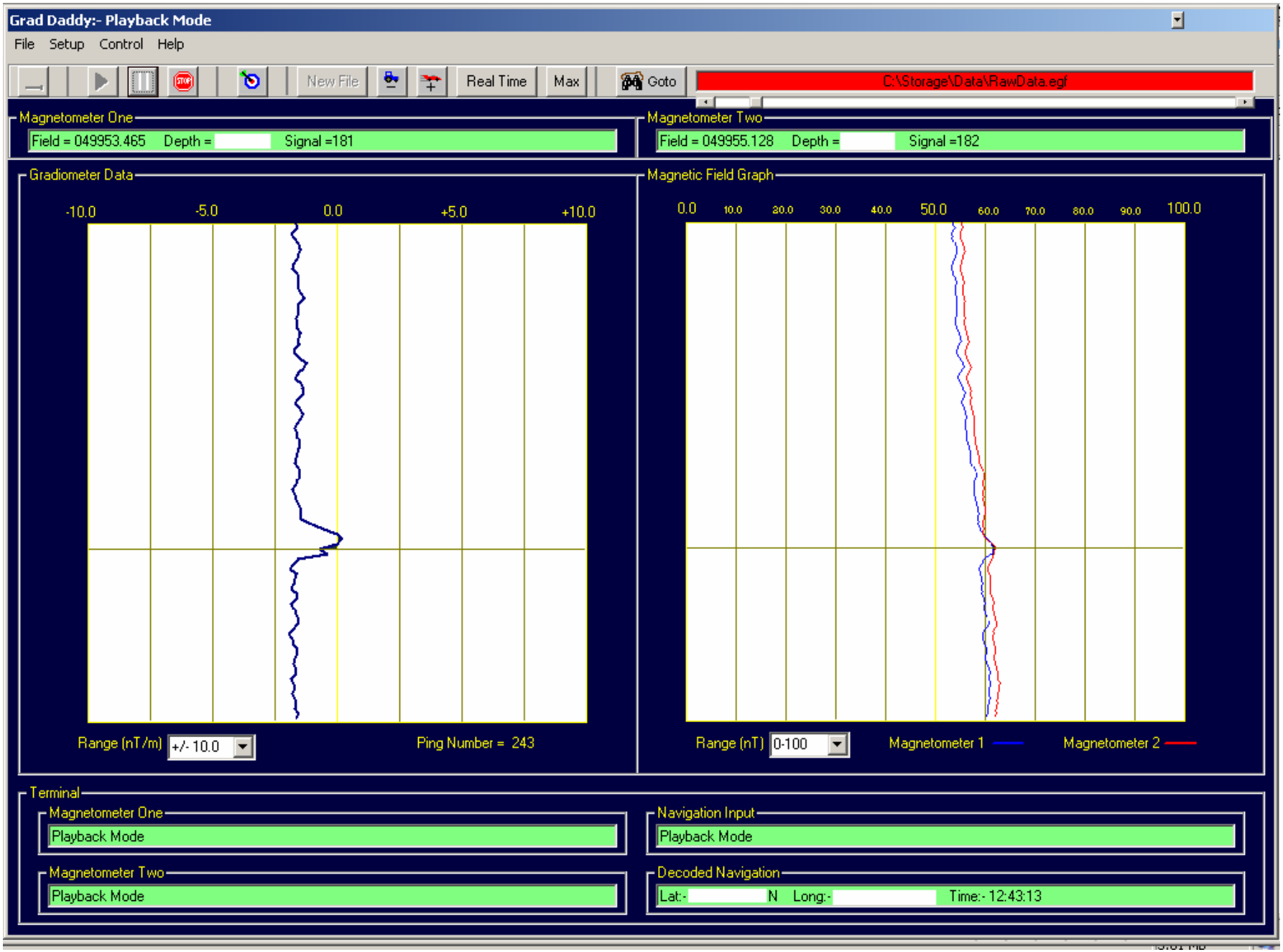
Development of the GSE Gradiometer

- Had to be able to use readily available sensors – MMC Explorer Overhauser
- Lightweight and compact.
- Low vibration.
- Flexible configuration - transverse or a vertical gradiometer.
- By the addition of an interface bottle this system had to be able to be towed behind a Klein 3000 digital sidescan.

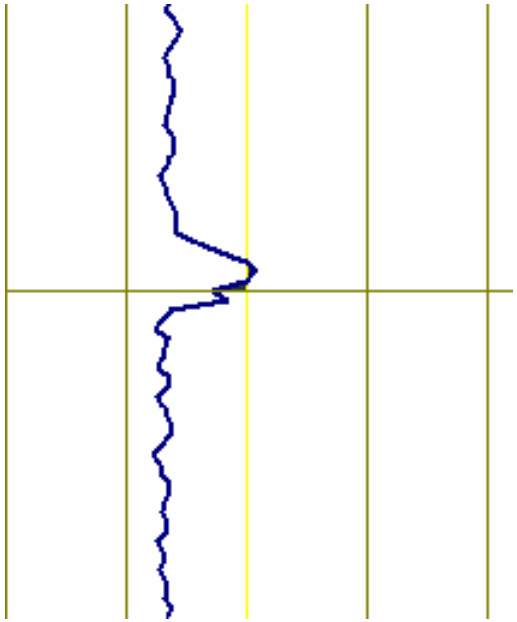
GSE Rentals Gradiometer

Acquisition Software

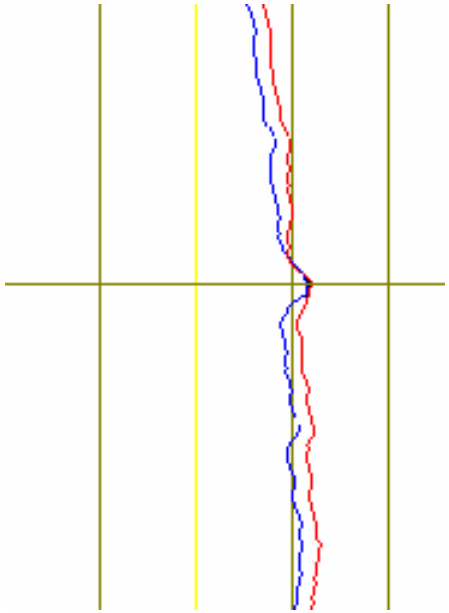
- Real time scrolling display.
- Logs raw sensor data as well as calculated gradient values.
- Synchronisation of the Overhauser Sensors.
- Flexible interfacing capabilities.


Grad Daddy:- Playback Mode
File
Setup
Control
Help
New File
Real Time
Max
Goto
C:\Storage\Data\RawData.egf
Magnetometer One
Field = 049953.465
Depth =
Signal =181
Magnetometer Two
Field = 049955.128
Depth =
Signal =182
Gradiometer Data
-10.0
-5.0
0.0
+5.0
+10.0
Range (nT/m)
+/- 10.0
Ping Number = 243
Magnetic Field Graph
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Range (nT)
0-100
Magnetometer 1
Magnetometer 2
Terminal
Magnetometer One
Playback Mode
Magnetometer Two
Playback Mode
Navigation Input
Playback Mode
Decoded Navigation
Lat:-
N
Long:-
Time:- 12:43:13

Gradiometer display



Magnetometer Display



Some obvious things to consider when planning the survey…..

- What size and type of target do you have to detect?
- What is the water depth and the seabed topography like?
- What vessel can you use? Is it magnetic and can you deploy the system far enough away?
- Is the survey location in a difficult magnetic environment i.e. a harbour or near a platform?

To Conclude

- Pulse induced systems are only really effective in small areas where range is not an issue or not desirable (canal, small harbours). This has to be the system of choice for non ferrous conducting targets.

- Single magnetometers may be used to find large targets at relatively good range but have difficulty in discriminating small targets against background noise.

- Gradiometers are a particularly effective tool for the detection of small ferrous targets.

Thank you