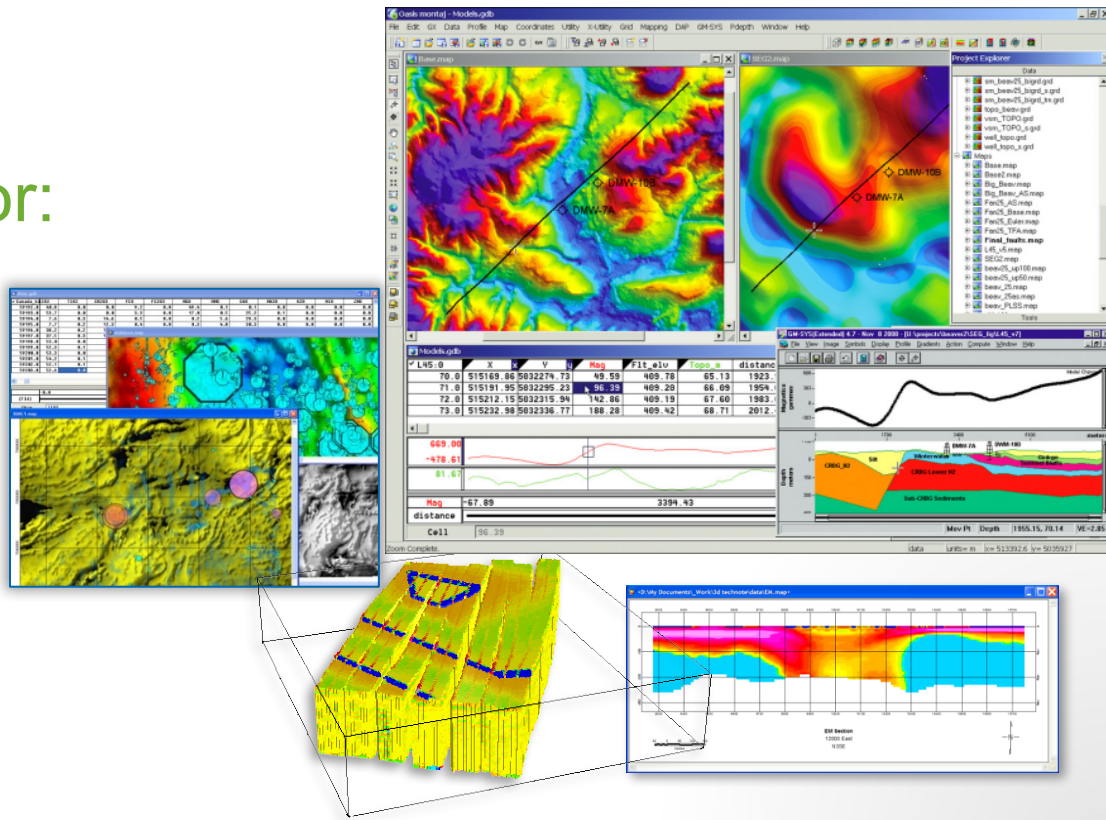




Geoscience software for:

- Geophysics
- Geochemistry
- Geology
- GIS



How does Geosoft use EM & Electrical methods?



IP & DC resistivity

- QC, processing and 3D pseudosection visualization
- 3D inversion

FDEM

- Visualization and basic processing
- FDEM pseudo 3D inversion

TDEM for UXO –EM61 MK2, (3-4 time gates)

- Import, processing, target picking, depth estimates 7 forward modelling

TDEM for UXO – Geometrics - Metal Mapper

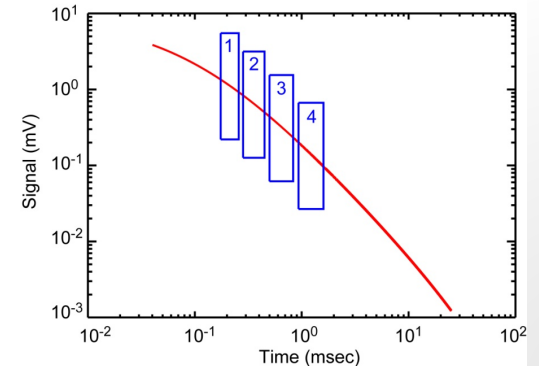
- Dynamic surveys for target locating
 - Processing, target picking, depth estimates, high level classification (21 time gates)
- Static surveys for classification
 - Ordinance classification (122 time gates)

Conventional EM Sensors

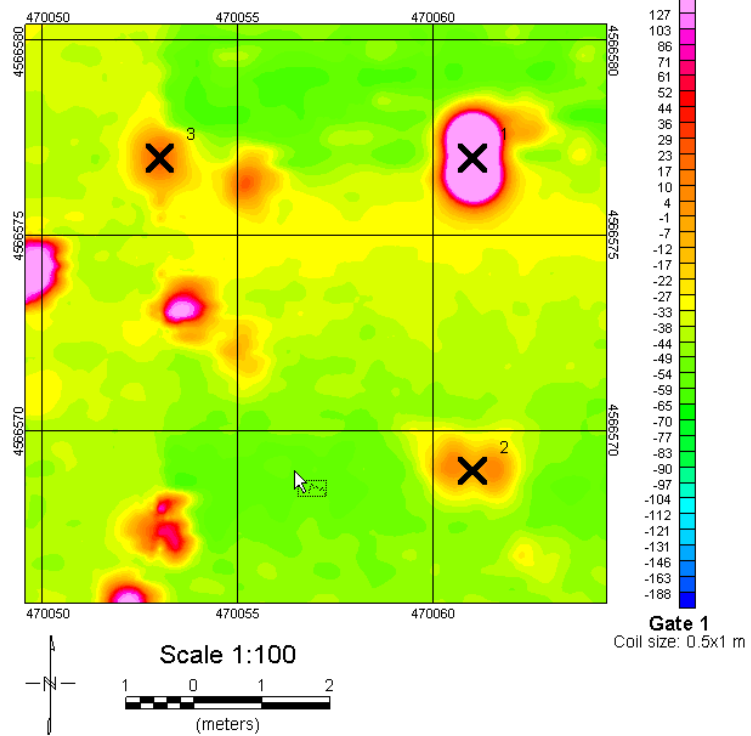
Not usually good for classification

- Coarse measurement of eddy current decay (four time windows or gates)
- Point response measured at series of locations must be combined to fully interrogate target
- Small sensor location errors (~ 1 cm) compromise ability to estimate polarizability

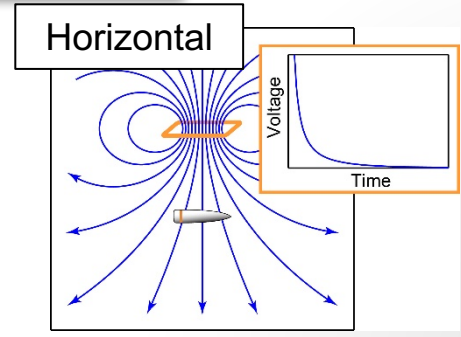
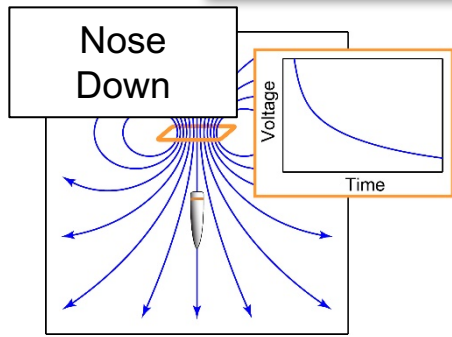
(some simple case exceptions)



Conventional EM Sensors

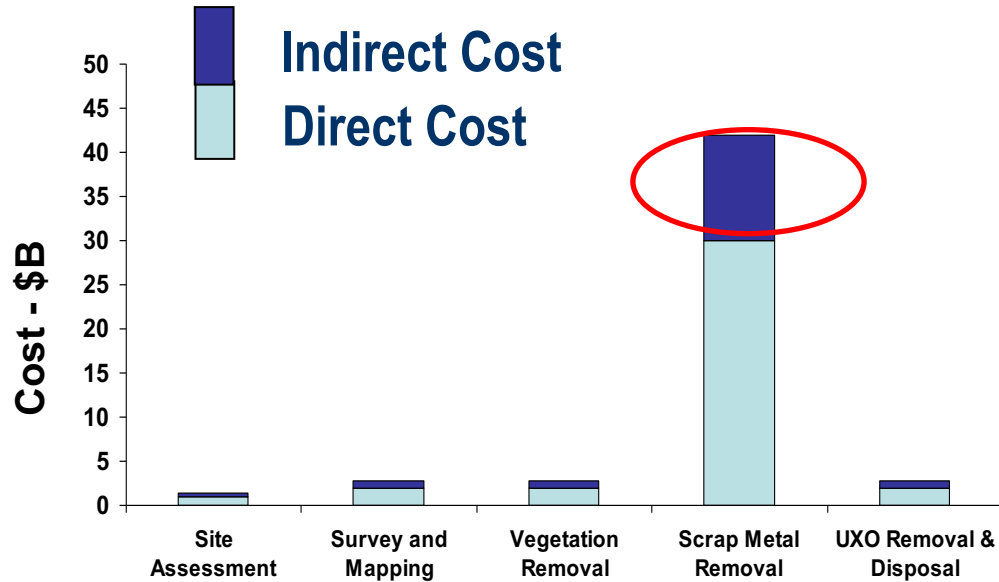


Parameter Values	
Target 1	
X (metre):	4
Y (metre):	4
Size:	2.75" ROCKET
Distance below sensor (metre):	0.6
Inc (deg):	0
Dec (deg):	0
Roll (deg):	0
Target 2	
X (metre):	4
Y (metre):	-4
Size:	2.75" ROCKET
Distance below sensor (metre):	1.2
Inc (deg):	0
Dec (deg):	90
Roll (deg):	0
Target 3	
X (metre):	-4
Y (metre):	4
Size:	2.75" ROCKET
Distance below sensor (metre):	1.5
Inc (deg):	90
Dec (deg):	0
Roll (deg):	0



Why Do Classification?

Munitions Response Typical Cost Breakout

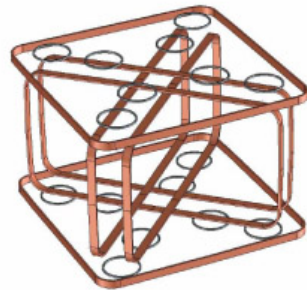


Advanced EM Sensors

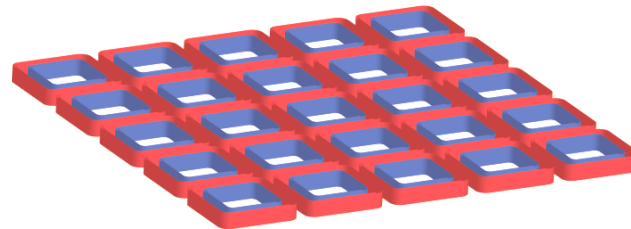
Designed for Classification

To observe the complete EM response pattern the object must be excited and measured from all directions

- multi-axis coil sensors or
- single axis coil arrays



Multi-axis coil array



**Single axis planar
array**

Advanced EM Sensors



MetalMapper

- 3 multi-axis transmitters
- 7 multi-axis receivers



MetalMapper 2x2

- 4 coil transmitter array
- 4 multi-axis receivers



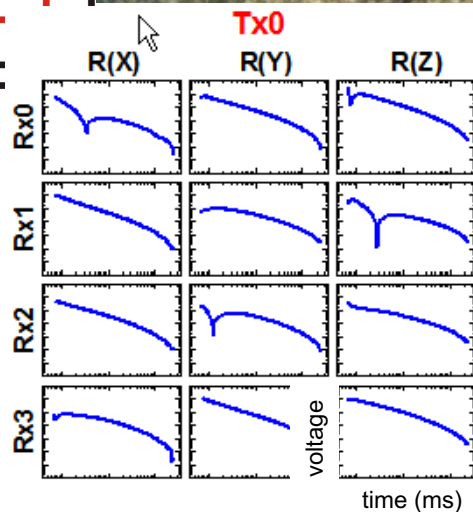
Typical static survey mode, 122 gates over 25ms

Extracting 'Intrinsic' Features

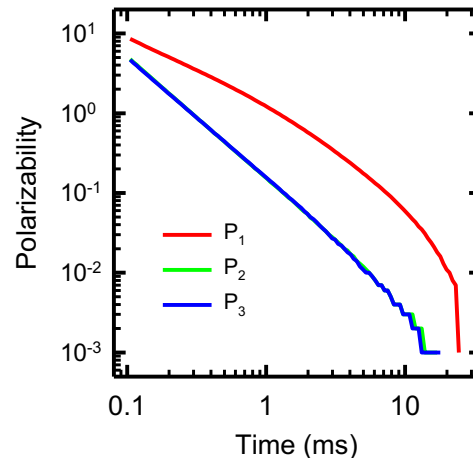
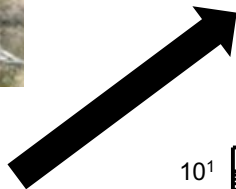
Plan view of 2x2 sensor



Transients from Rx cube



Dipole Response Model
Inverse Operation



Polarizability's

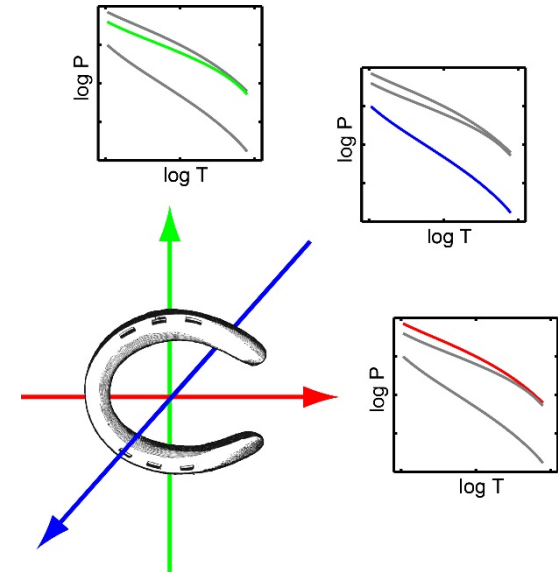
The solution for classification – intrinsic features

EM response is decomposed into components along three orthogonal principal axis directions

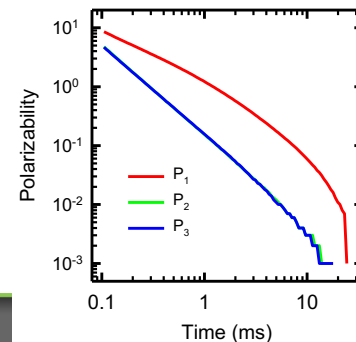
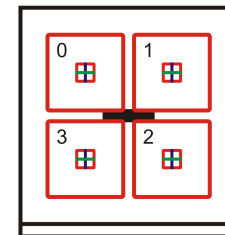
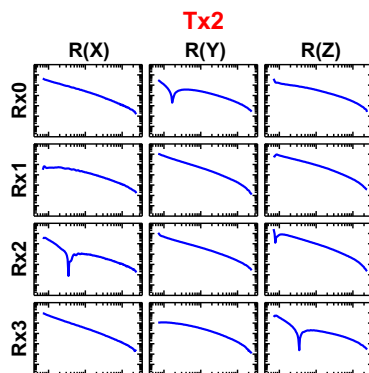
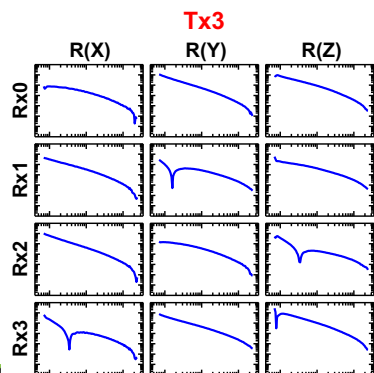
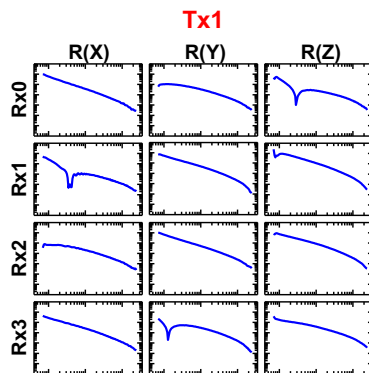
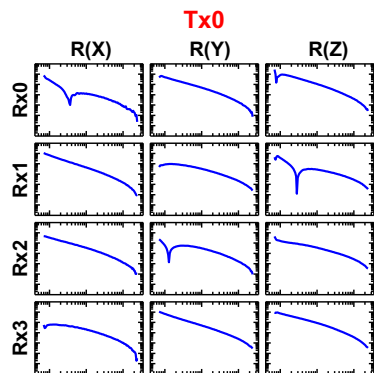
- Principal axis *directions* correspond to fundamental excitation modes of target
- Magnetic *polarizabilities* are specific responses to unit excitation along each of target's principal axis

Principal axis polarizabilities

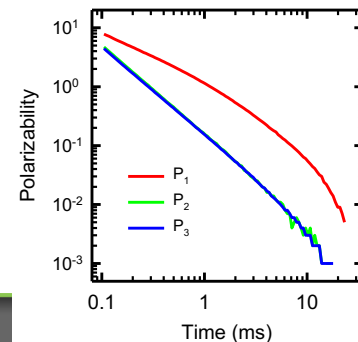
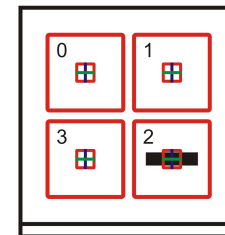
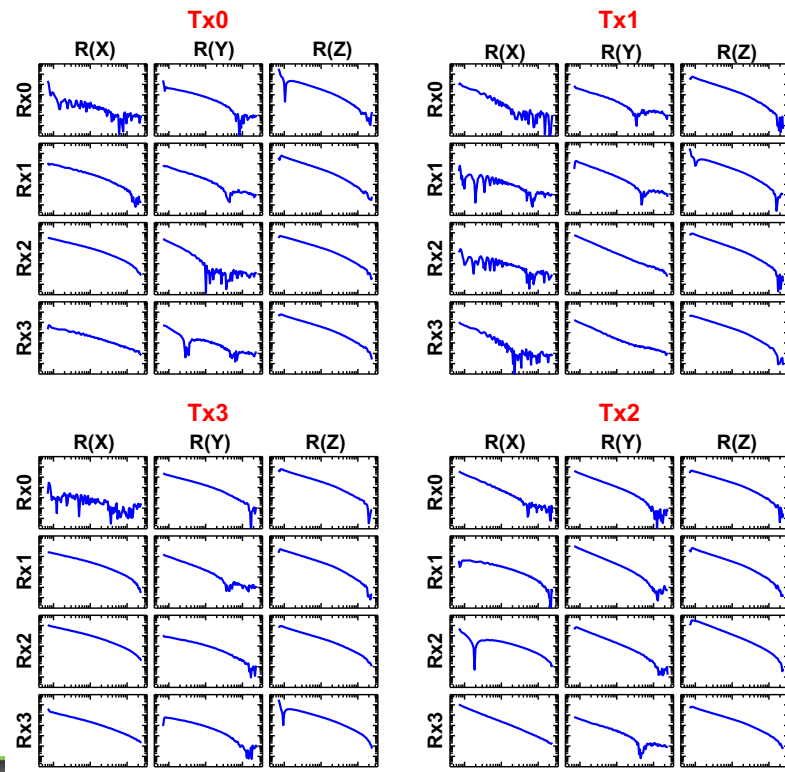
- Completely describe EM response of target
- Intrinsic to the source



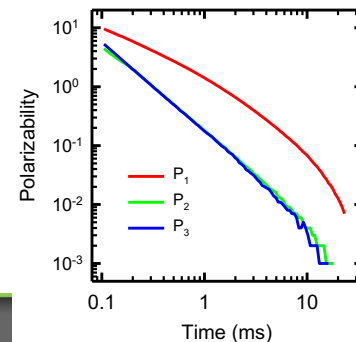
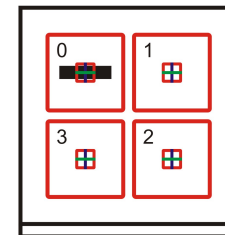
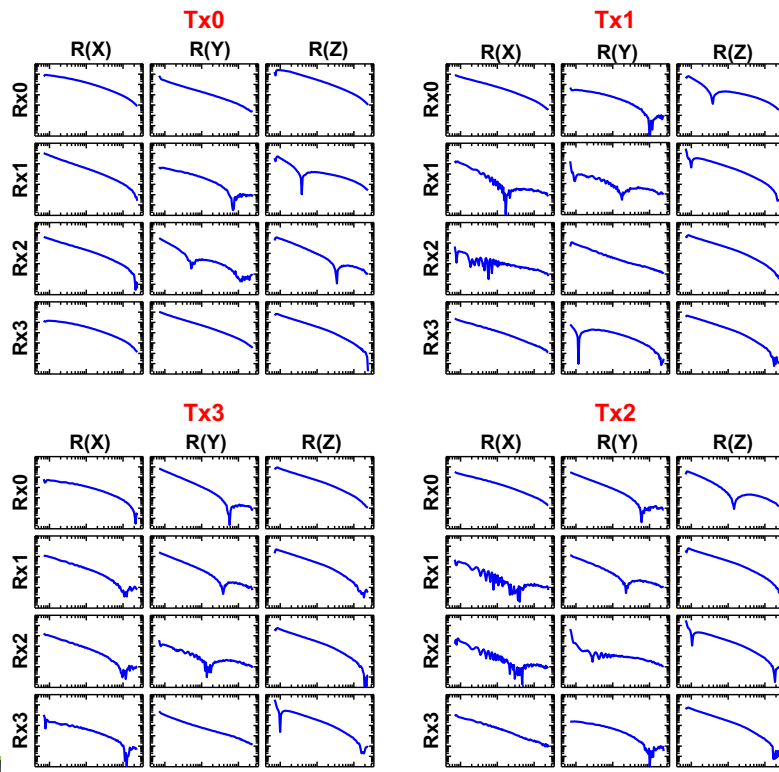
Measured Decays Convolve Intrinsic Response with Relative Position and Orientation – Position “A”



Measured Decays Convolve Intrinsic Response with Relative Position and Orientation – Position “B”



Measured Decays Convolve Intrinsic Response with Relative Position and Orientation – Position “C”

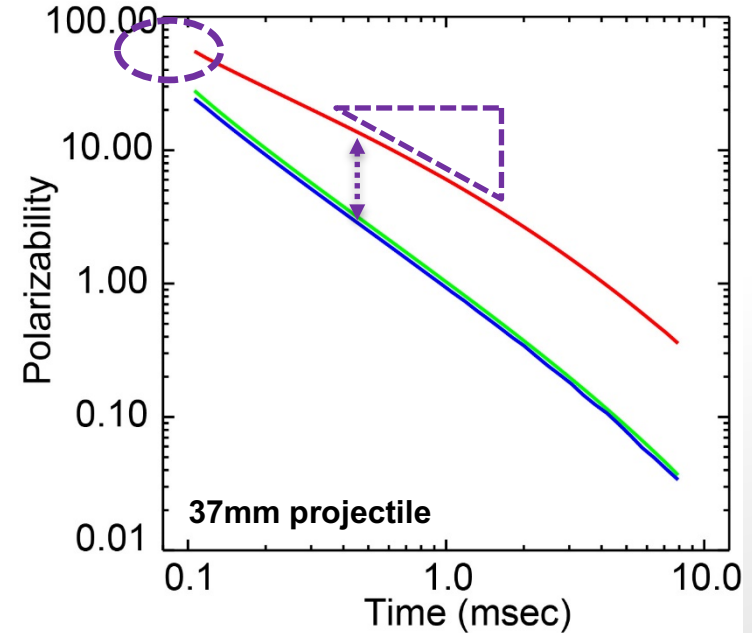


Polarizabilities

Principal axis polarizabilities completely describe EM response of target

- intrinsic to the target
- invariant to burial depth or target orientation

Polarizability Property	Target Property
Decay Rate	Wall Thickness
Relative Magnitude	Shape
Total Magnitude	Size (volume)

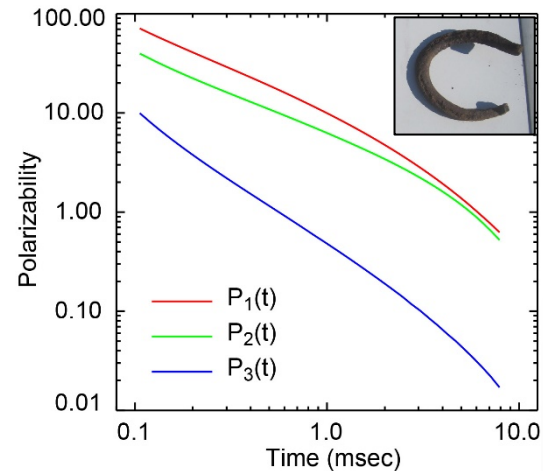
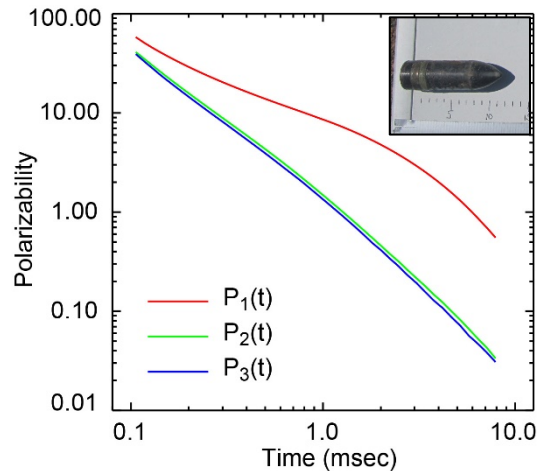


Classification

Signature Matching

What an unknown target “looks like” in EM sense

- Compares polarizability against bank of signatures for expected munitions and other training objects



Classification

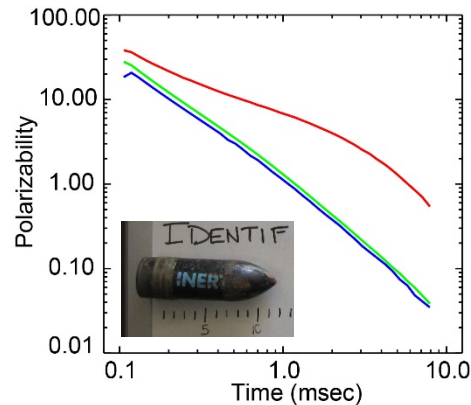
Signature Variability

EM signatures of nominally identical items can differ

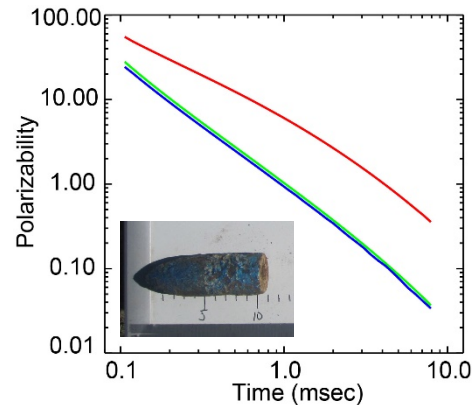
- Different subtypes, damage, inversion errors due to noise

Matching procedures must tolerate some variability

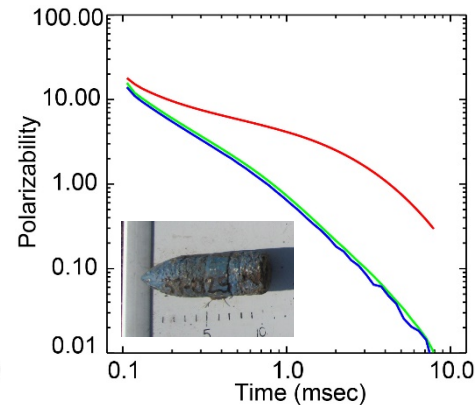
e.g. 37mm projectile rotating band effects



band at base



band missing



band in middle

Ranked Source List



Classify and Rank Sources

- Combine match metric
- Size and Decay
- Signal amplitude
- Source to array distance

Initial Ranked Anomaly List

Anomaly ID	Dig on First Pass	Type	Comment
2498	Y		Unable to extract reliable parameters
247	Y	105 mm	
1114	Y	4.2 in	High likelihood TOI
69	Y	155 mm	
811	Y	81 mm	
313	N		Unable to classify
883	N		
...	N		
...	N		
...	N		High likelihood not TOI
...	N		
...	N		
...	N		
...	N		
...	N		
...	N		
...	N		

First Pass Threshold

Final Ranked Anomaly List

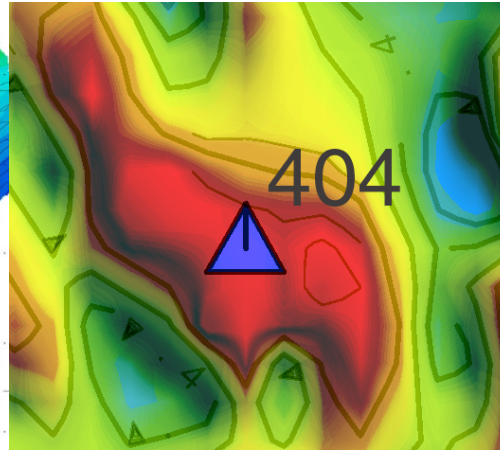
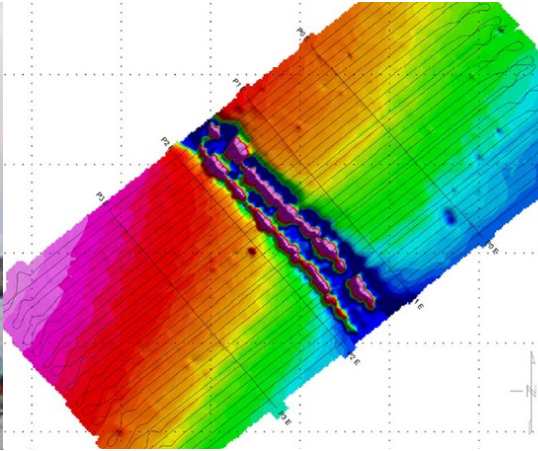
Anomaly ID	Dig	Type
2498	Y	
247	Y	105 mm
1114	Y	4.2 in
69	Y	155 mm
811	Y	81 mm
313	Y	105 mm
883	N	
...	N	
...	N	
...	N	
...	N	
...	N	
...	N	
...	N	
...	N	
...	N	
...	N	

Final Threshold

Future plans and challenges?



- Marine EM
 - Develop our current tools for EM61 to be marine compatible
 - Work with Geometrics to develop an advanced EM system for classification
- 3D TDEM inversion



Please visit Geosoft at Booth G8

or visit www.Geosoft.com