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MEC Detection Technologies
(Geophysics 101)

Army IRP/MMRP Workshop
Baltimore, MD
2007

Innovative Technologies Program Manager (acting)
U S Army Engineering & Support Center, Huntsville

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Outline

- Introduction & Overview
- Geophysics 101
- Why geophysics?
- What works and what doesn't
- Theory (on the "what works")
- A few words on navigation
- How we use Geophysics to characterize and clean-up a site (the quick version)
- Examples of field work and data products (the good, the bad, and the ugly)
- New Stuff

Why is geophysics important to munitions response projects?

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- There are only <u>two</u> ways to clean-up MEC
  - Detect the buried stuff and dig it up
  - Dig <u>everything</u> up and sift for the MEC

Former Lowry Bombing & Gunnery Range

Normandy

Bosnia

Southwest Proving Grounds

Ft Ord

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Importance of the Geophysical Investigation

The geophysical investigation is the most critical part of a UXO investigation

- During Characterization
  - IDs type of problem
  - IDs extent of problem
- During Removal
  - Detection and Selection

Decisions impact

- Total project costs
- The quality of the removal action
- Future public safety

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What Is at Risk…

- A poorly planned and executed geophysical investigation will most likely produce:
  - Undocumented, unusable and misleading information, leading to
  - Indefensible predictions and conclusions
- Erroneous conclusions result in:
  - Recurring site revisits and expenses
  - Poor public and professional reputation
  - Safety hazard

What Is at Risk… (example from Spring Valley FUDS)

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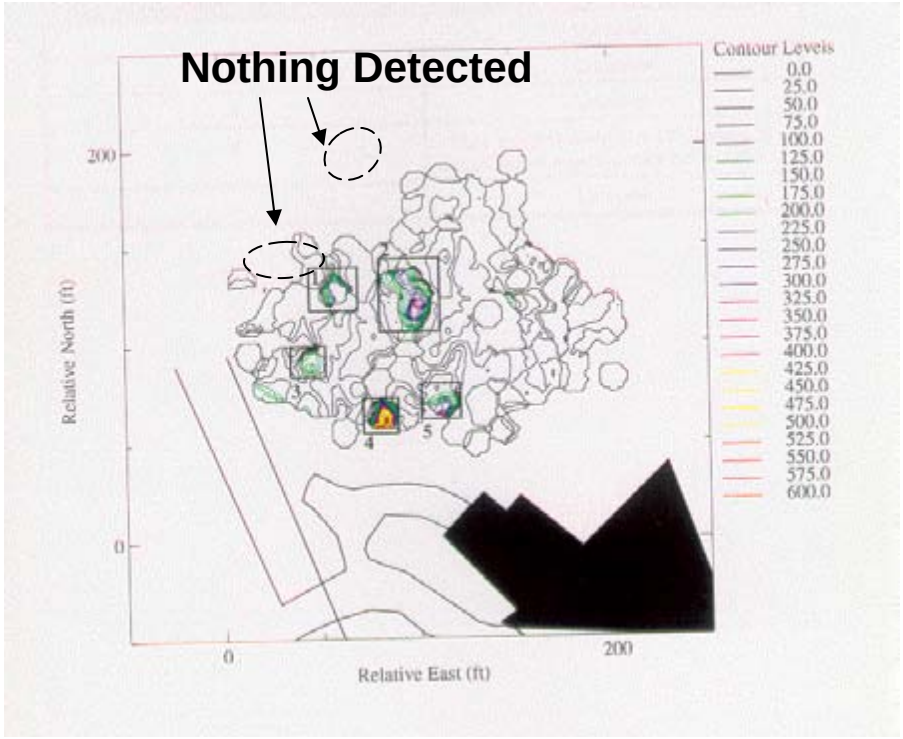
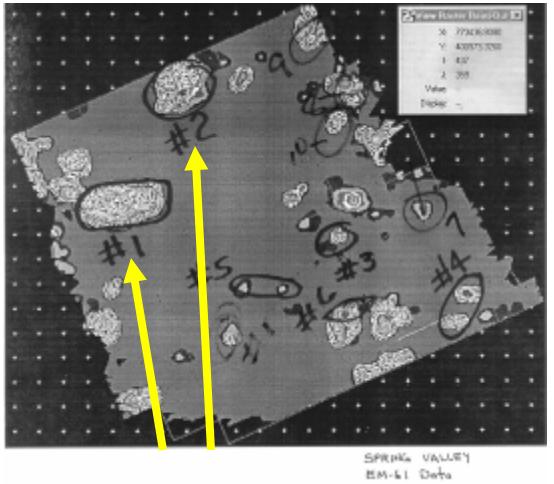


4801 Glenbrook geophysics
1994



Recovered Chemical Warfare Munitions Disposal Pits-Circa 1918

4801 Glenbrook geophysics
1998

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DoD/EPA Mandate

- Permanent record required
  - Geophysical data must be digitally recorded and georeferenced to the maximum extent practical.
  - A clear audit trail of pertinent data, analysis, and decisions must be created.

Full project costs should be considered

All costs for activities that flow from the initial geophysical investigation must be considered (these costs can be more than the actual geophysical investigation).

A poorly planned and executed geophysical investigation does not save money.

Department of Defense and U.S. Environmental Protection Agency
Management Principles for Implementing Response Actions at Closed, Transferring, and Transferred Ranges, Interim Final, March 7, 2000

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OK, so what is geophysics?

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What is Geophysics? How is it used on MMRPs?

- Geophysics for MEC is the science of remote sensing on and beneath the ground surface
- Measure physical properties of the earth at, or near, the earth's surface
- For munitions response projects:
  - try to detect changes in magnetic fields caused by buried MEC
  - Look for topographic features (craters, targets)
  - On occasion, will look at reflections of radar waves.

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The two most commonly used methods for detecting MEC

- Magnetic methods: A passive detection method that measures naturally occurring and man-made magnetic fields
- Electromagnetic methods: An active detection method that generates a signal, which in turn, induces buried metal to generate a magnetic field
  - Time Domain Electromagnetic Induction detection (TDEMI)
  - Frequency Domain Electromagnetic Induction detection (FDEMI)

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There are other detection methods

Many technologies have been evaluated:

- *ground-penetrating radar*
- *synthetic aperture radar*
- *Lidar*
- *acoustic systems*
- *infrared sensors*
- *explosives "sniffers"*
- *etc., etc., etc,*

Work well only for special circumstances and applications, if at all.

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How Magnetics and EM work

How magnetic methods work

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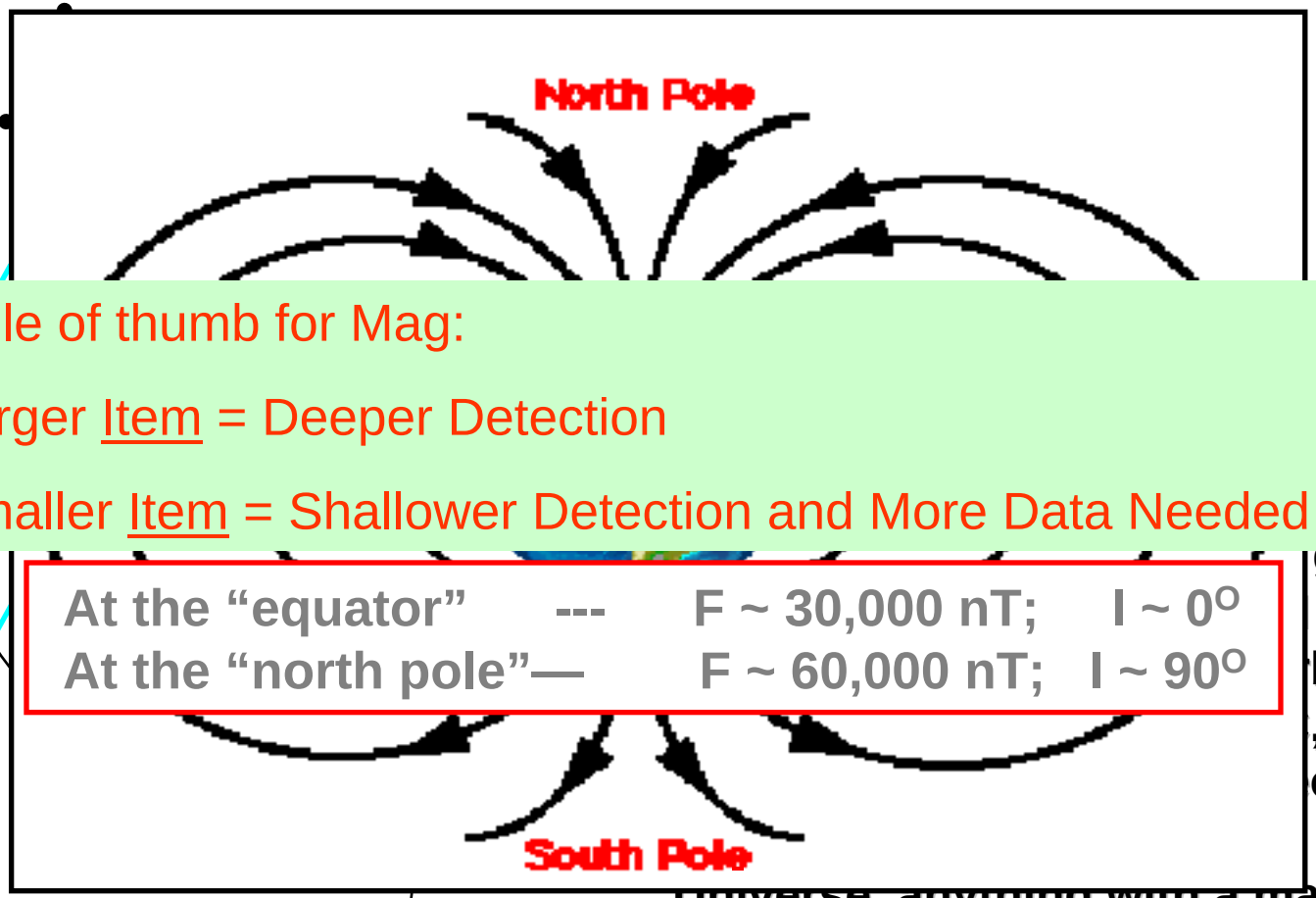

Rule of thumb for Mag:

Larger Item = Deeper Detection

Smaller Item = Shallower Detection and More Data Needed

At the "equator" --- F ~ 30,000 nT; I ~ 0°
At the "north pole"— F ~ 60,000 nT; I ~ 90°

al

given

by

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Universe, anything with a magnetic field.

What Magnetometer Systems Look Like in the Field

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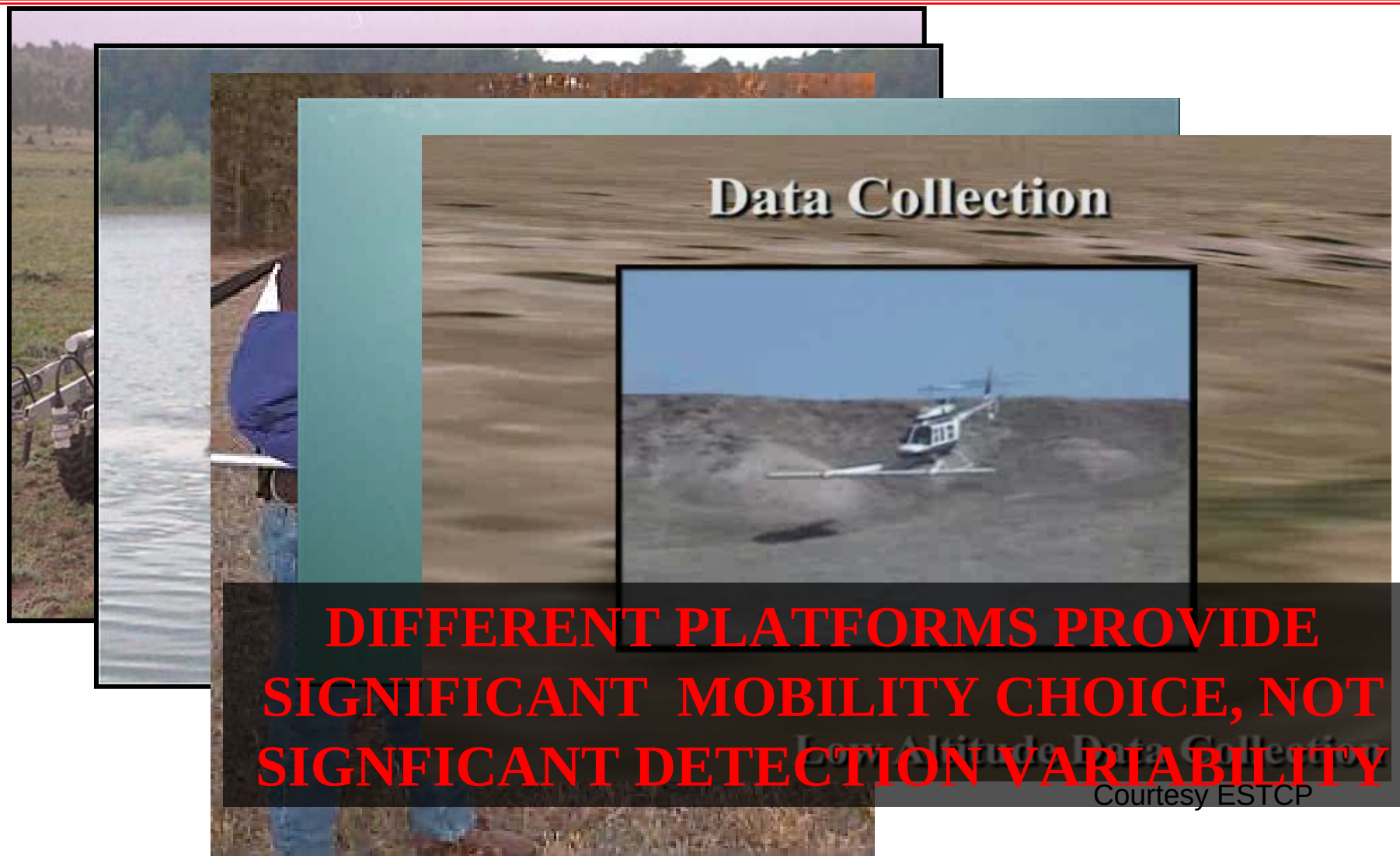
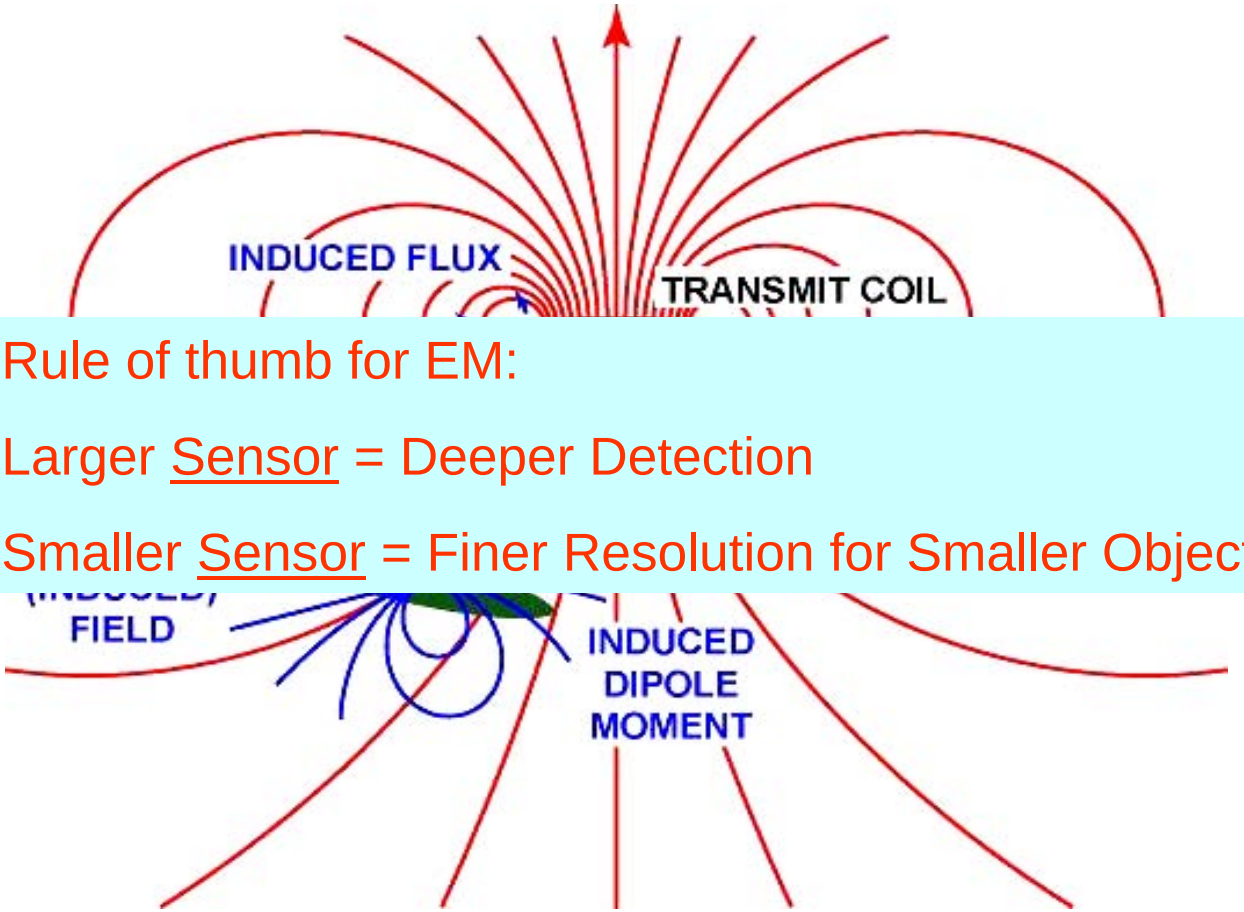


Courtesy ESTCP

How Time Domain Electromagnetic methods work



Rule of thumb for EM:

Larger Sensor = Deeper Detection

Smaller Sensor = Finer Resolution for Smaller Object

Figure courtesy Dr. Tom Bell

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Examples of Common Electromagnetic Induction

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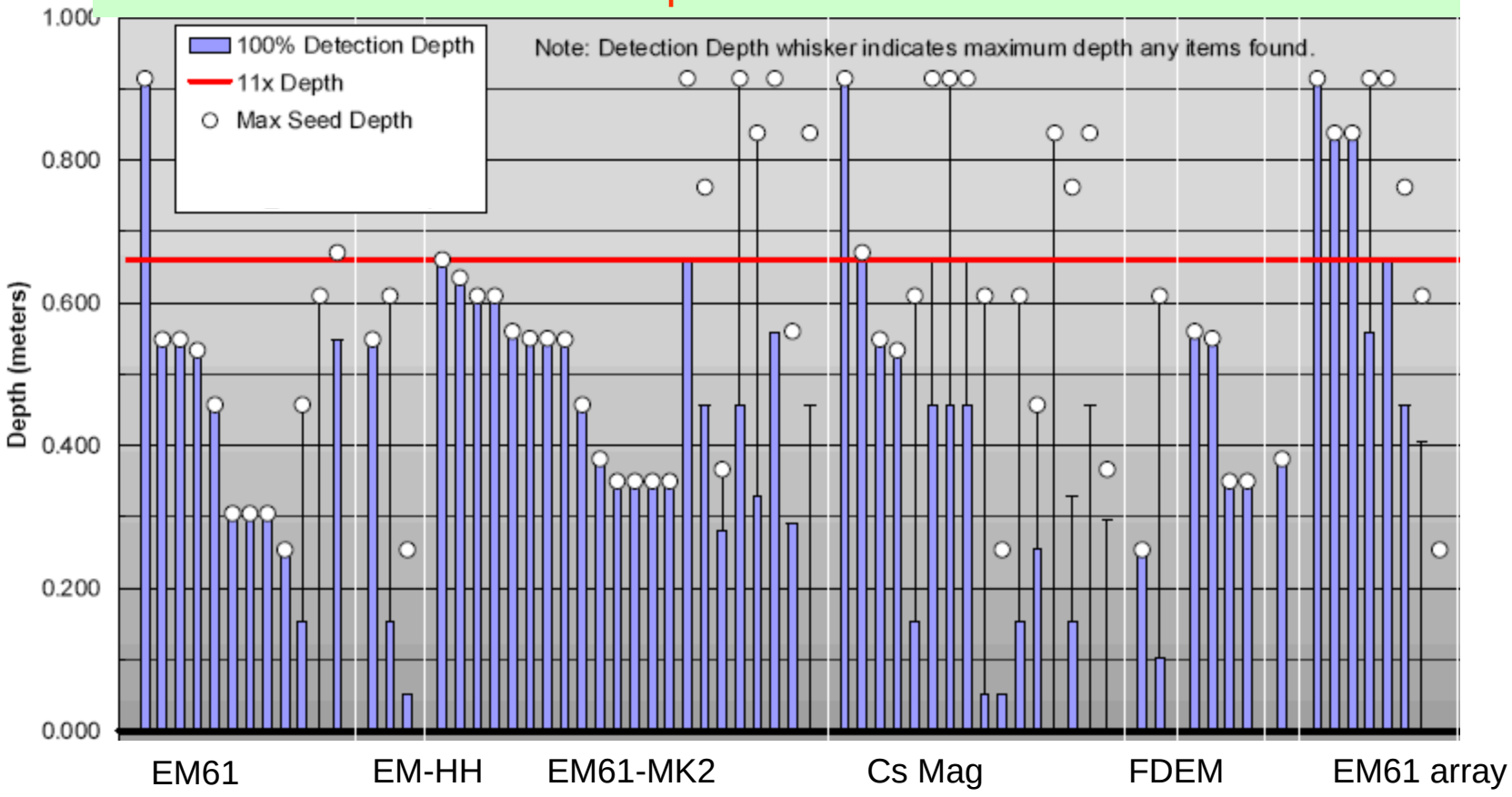
What TDEM methods look like in the field

Detection Capabilities Demonstrations – 60mm

Rule of thumb for detection capability:

Reliable Detection Depth Limit: ~11 x diameter of item



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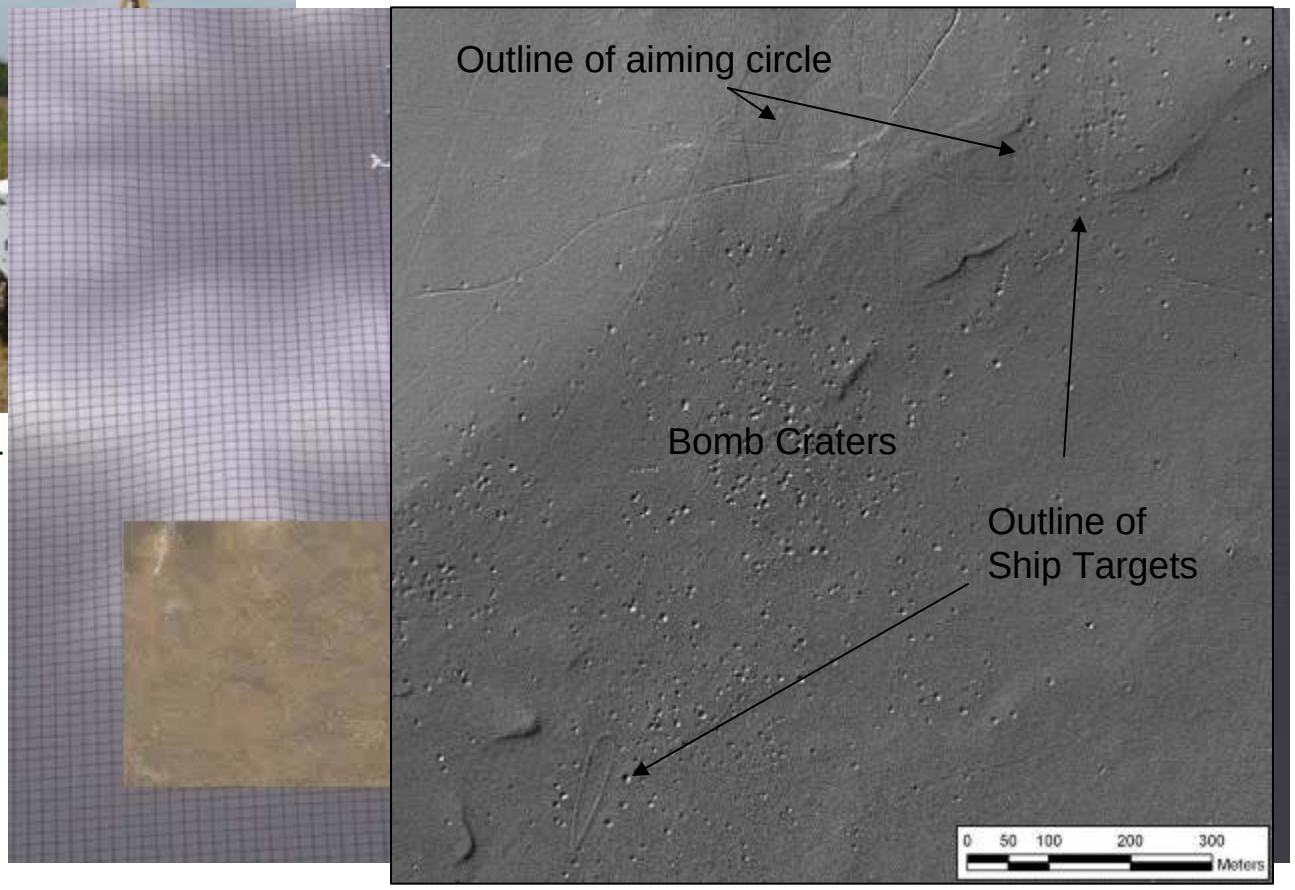
New Technologies & Recent Advances

Berkley UXO Discriminator
Funded by ESTCP



Courtesy ESTCP

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Some Examples of Geophysical Systems and Project Data

"The Good, The Bad and The Ugly!"

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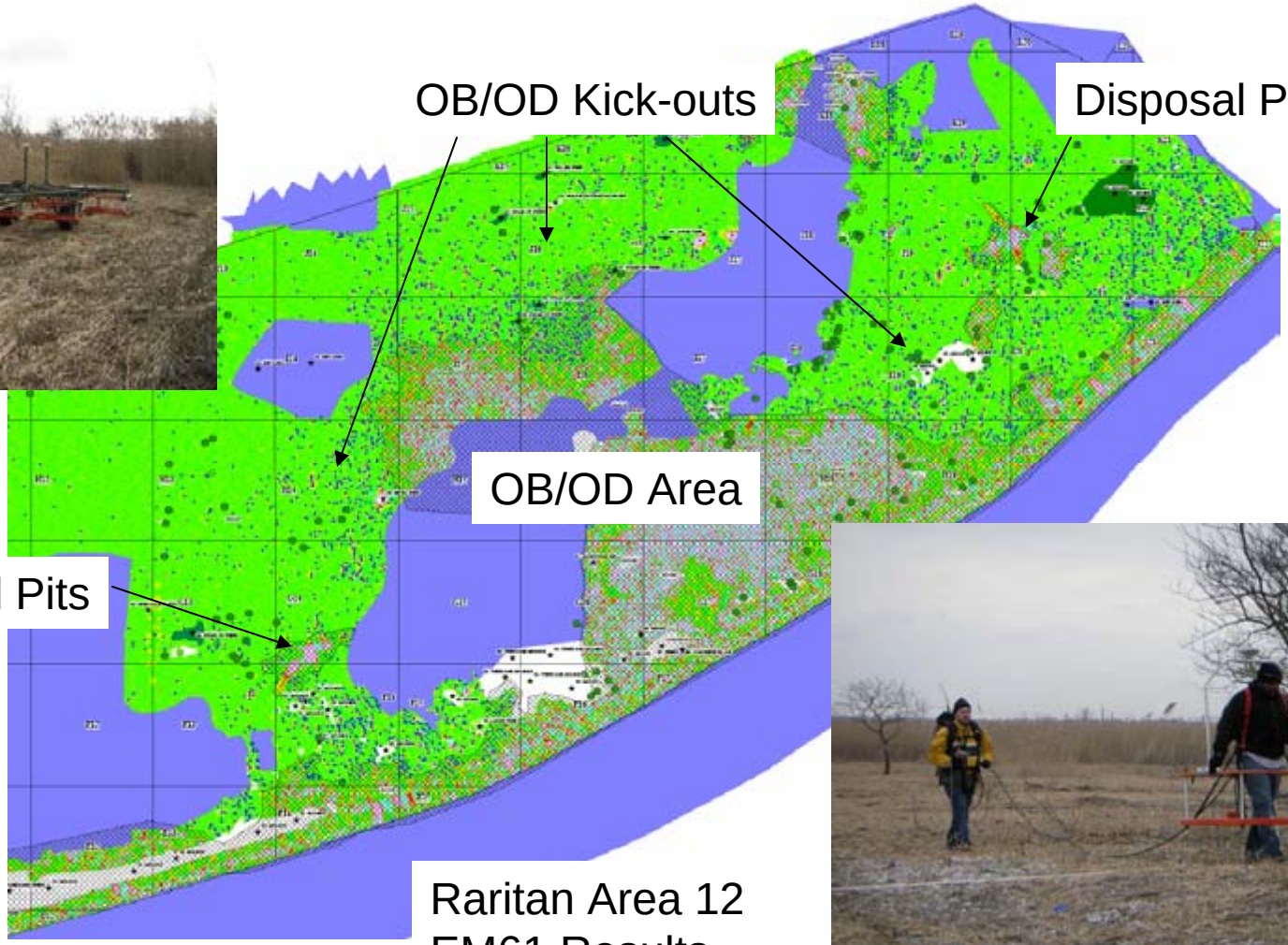
The Good
EM61 MK2 & DGPS



Raritan Area 12
EM61 Results

The Good (cont.)
Airborne mag

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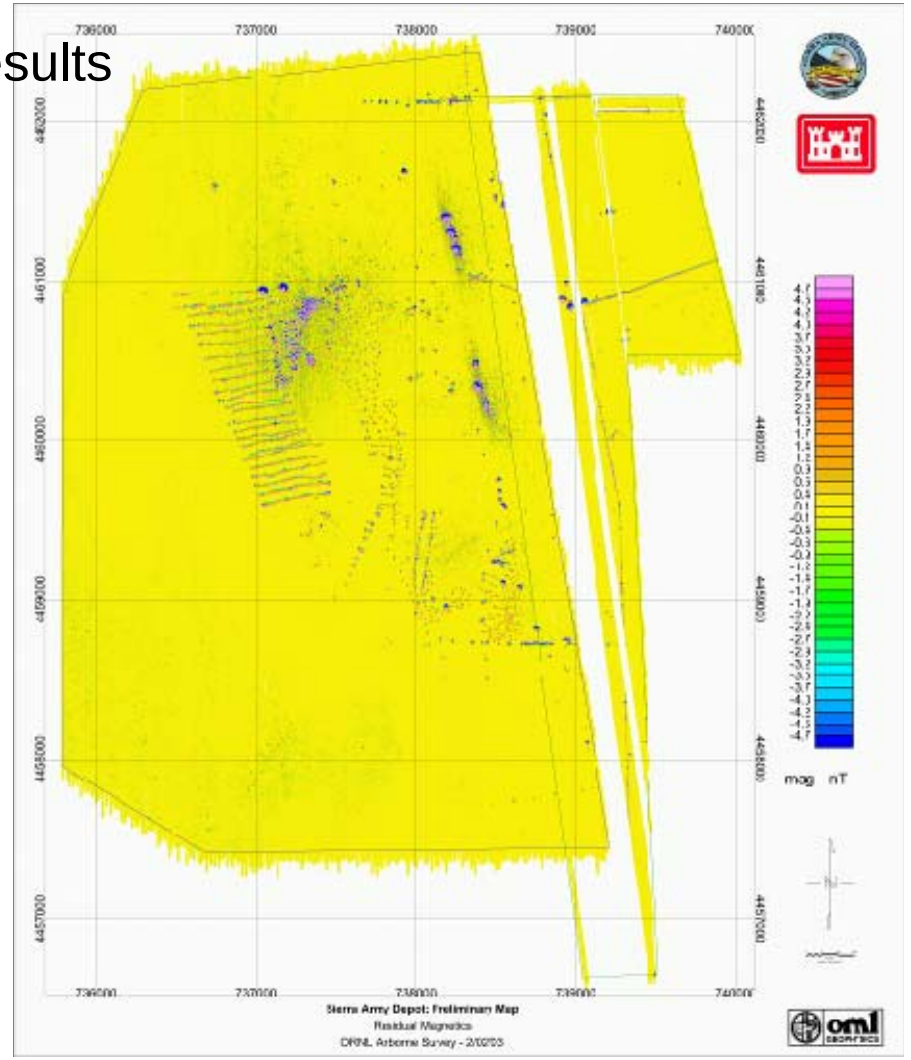
Airborne Magnetometer Results
Sierra Army Depot Activity
Honey Lake OB/OD area
(~5,000 acres)

Airborne magnetometer survey
Former Badlands Bombing Range



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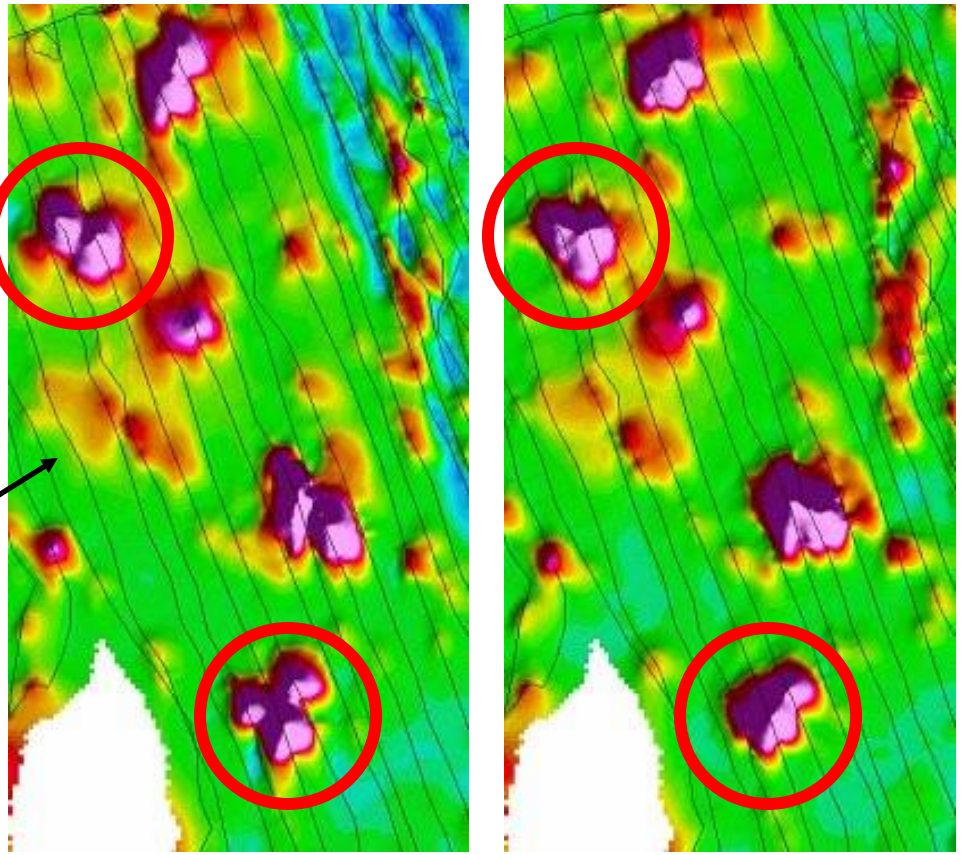
The Bad

Lag Problem

No Lag Problem



Survey track line

The Ugly
(but good data)

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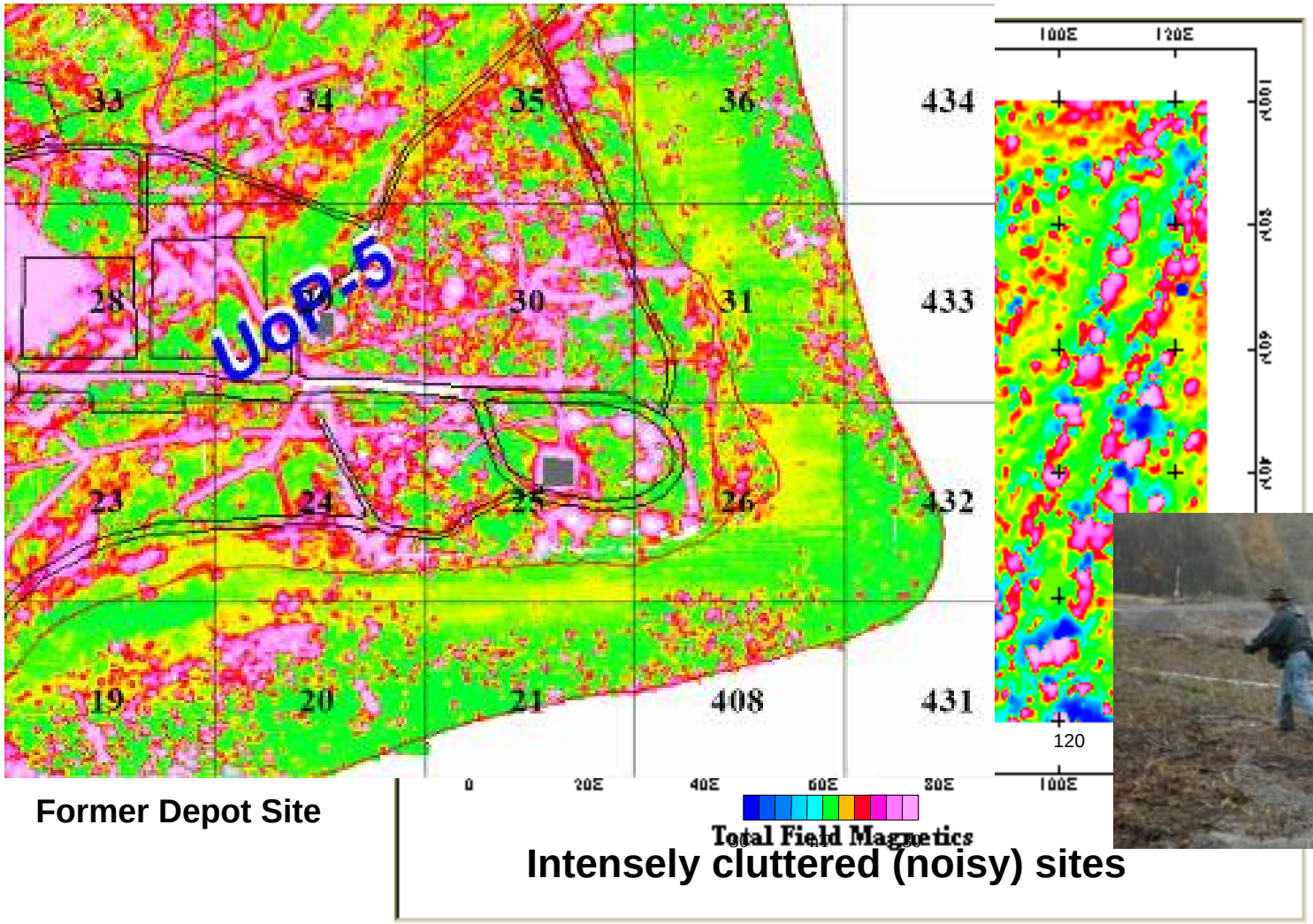

Former Depot Site

Intensely cluttered (noisy) sites

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THE UNEXPECTED!

UXO coarse aggregate in building foundation

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Overview of Anomaly Discrimination

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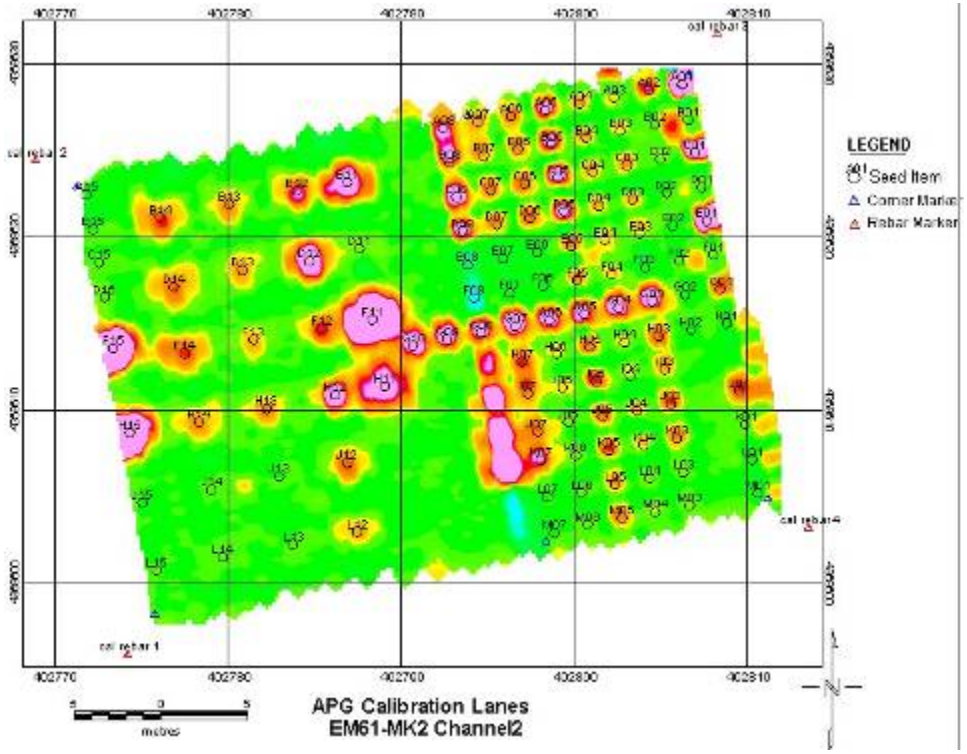
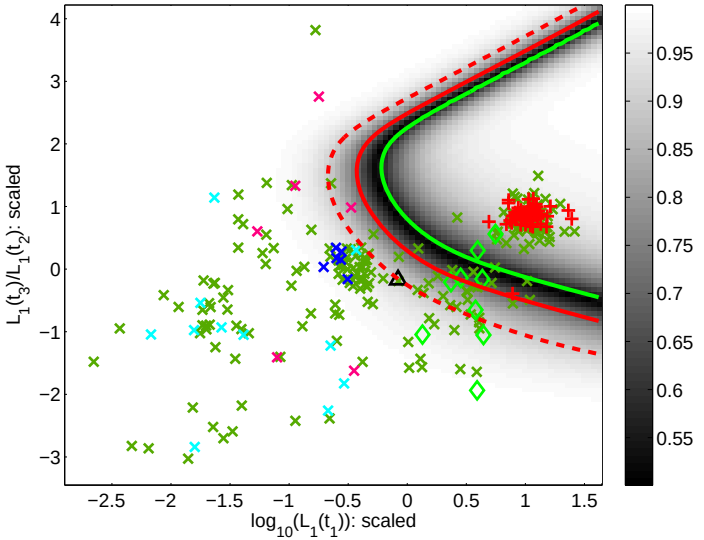
Anomaly Discrimination

All those pink blobs “look” the same. Which ones are bombs?





Feature Space Distribution
(Funded by ESTCP)

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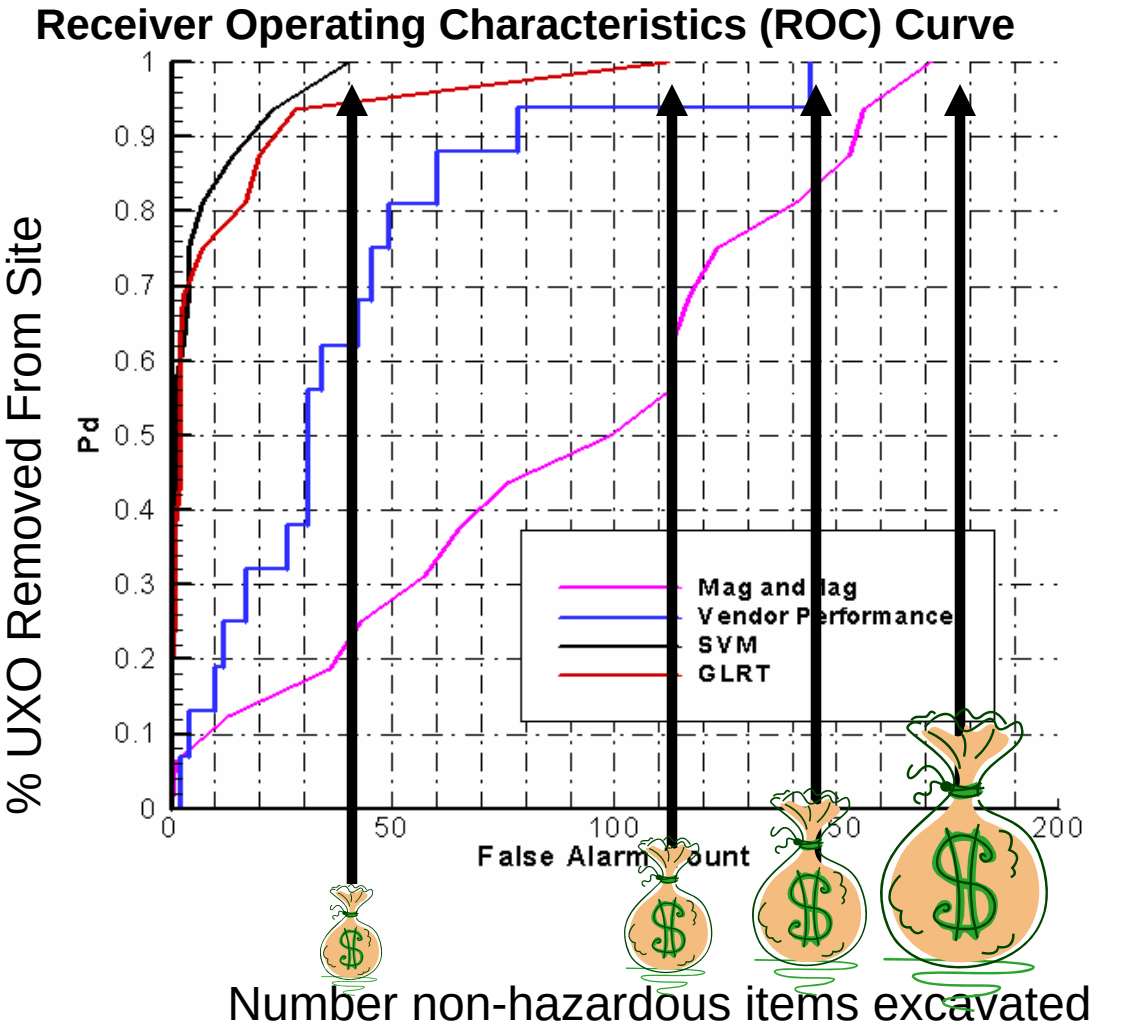
Why Anomaly Discrimination?



Duke University discrimination results using GEM-3 data collected at Jefferson Proving Grounds.

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Summary

- Geophysics is a critical component of the MMRP decision process
- We can get very good data and reliable answers
- Continue to improve and add tools to our remote sensing toolbox

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Contact

W-31 Trainer (inert) (early 1950's)

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