

# Geophex GEM-3 Array

# Single GEM-3 Sensor Configurations



Handheld (30-40cm dia)



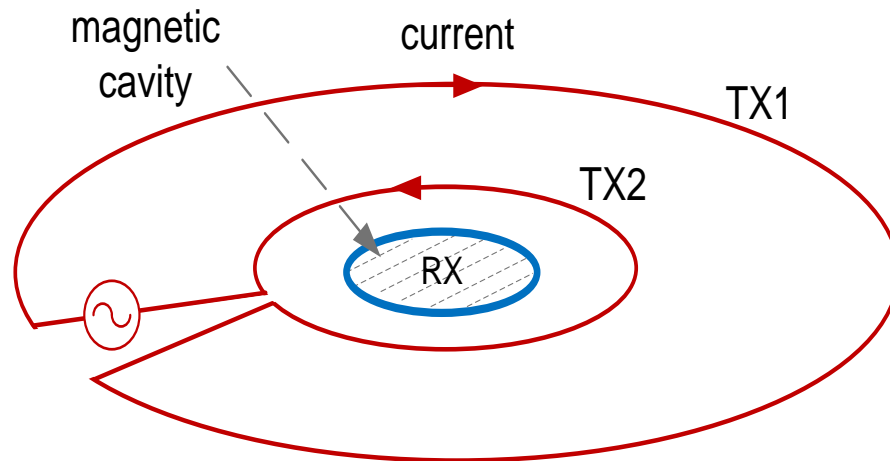
cart-mounted (48-96cm dia)



vehicle-towed  
(96cm dia)

## GEM-3 EMI Sensor Physics:

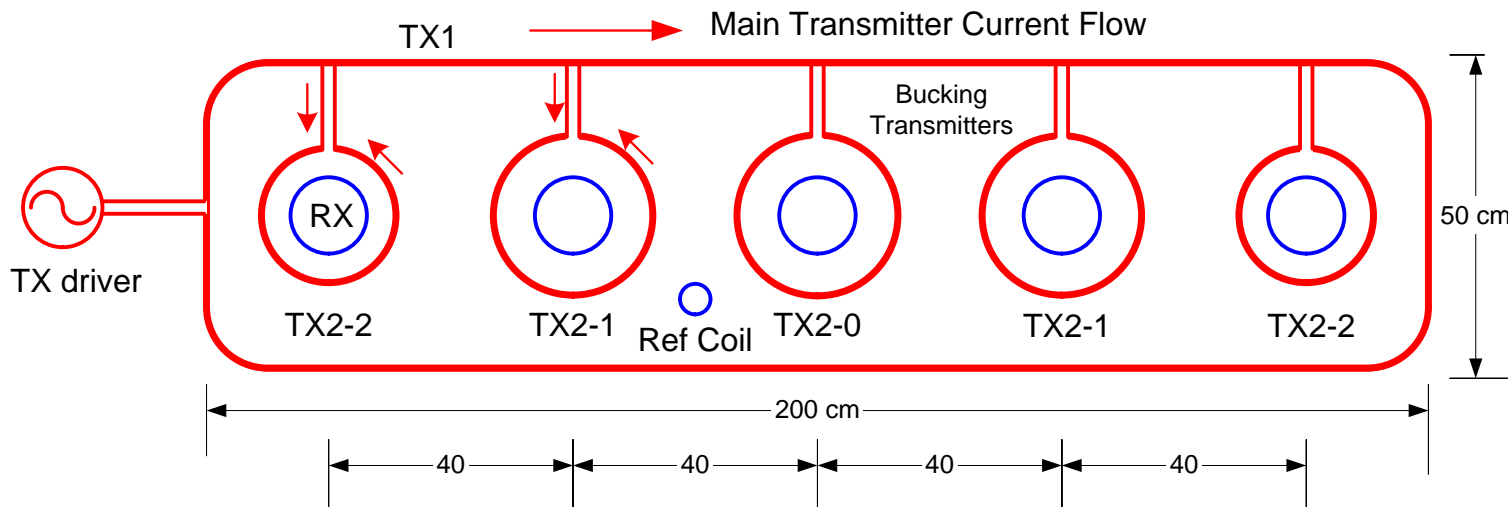
- Introduced in 1998 (US Patent No 5,557,206) by Geophex
- Concentric, co-planar, transmitter-bucked configuration
- The only programmable multi-frequency EMI sensor



TX1 is the primary source to illuminate the target. A small inner TX2 is connected to TX1 in an opposite polarity, creating a region of central “magnetic cavity” where the receiver coil (RX) is located so that it can sense a minute secondary field with a largest possible dynamic range.

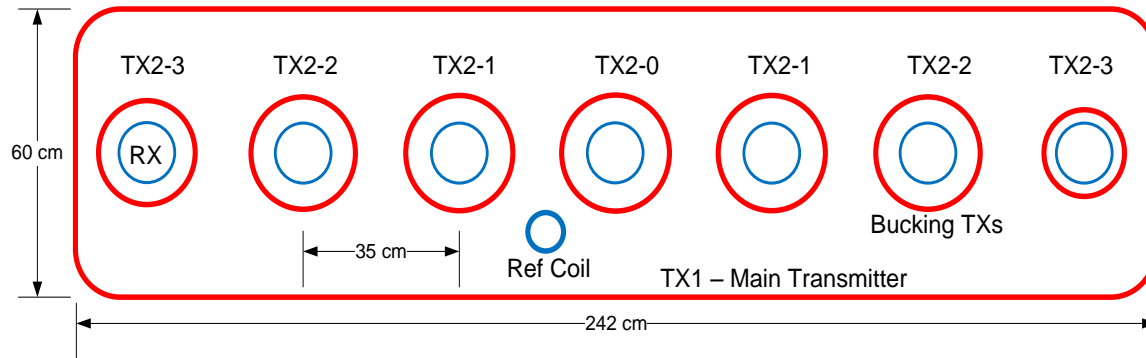
# GEM-3 Array Design

- Largest possible transmitter dipole moment for a given physical size of an array,
- Single transmitter driver simplifying the overall hardware,
- High overall sampling rate independent of the number of the receiver channels,
- High spatial data density and compact physical construction layout, and
- Broadband operation enabling potential target discrimination based on the patented Electromagnetic Induction Spectroscopy (EMIS).



RX dia = 12.5 cm for all  
 Diameters for:  
 TX2-0: 26.34 cm  
 TX2-1: 26.10 cm  
 TX2-2: 22.02 cm

TX1/TX2 Turn Ratio: 3:1  
 Dipole Loss: 7.8%

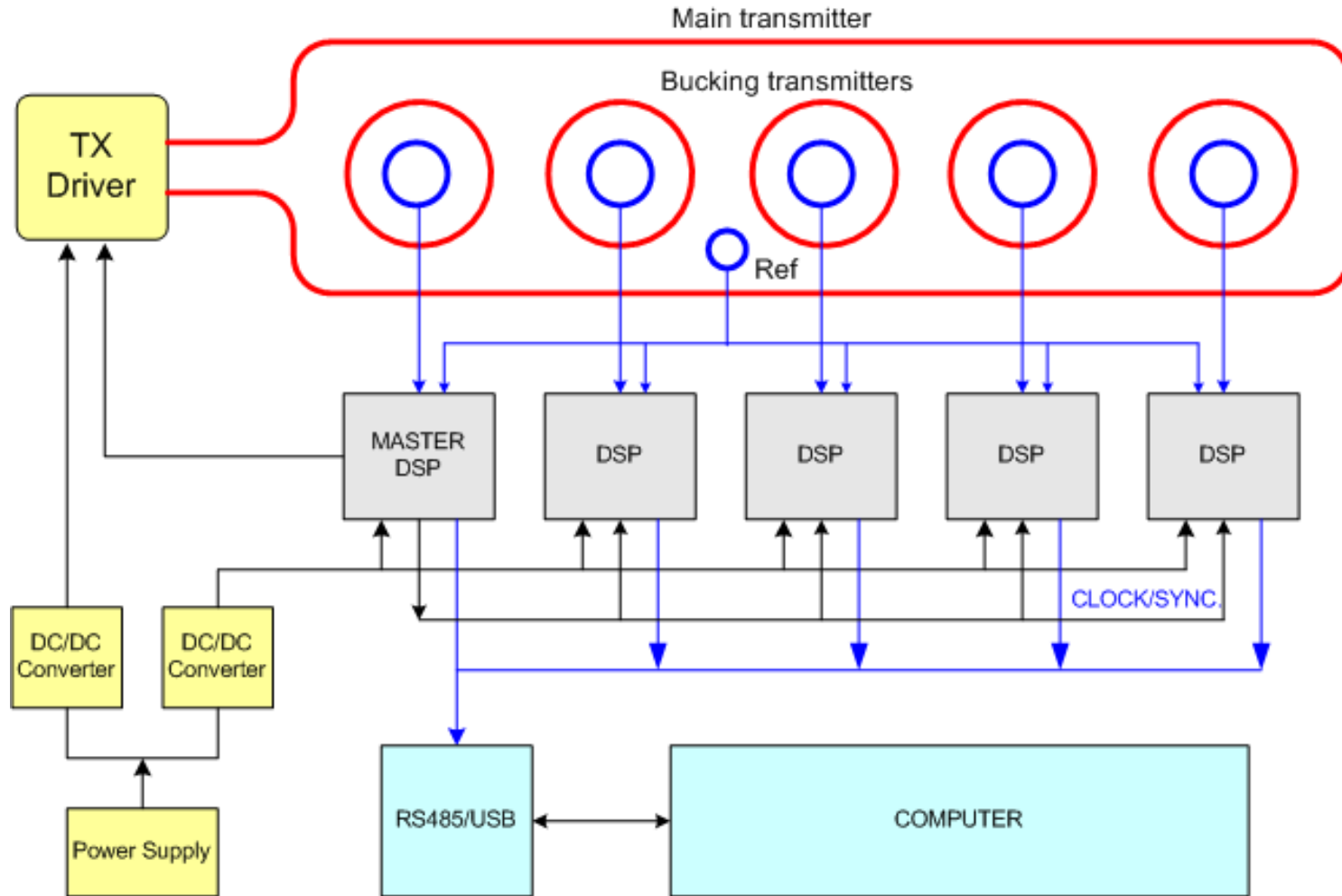


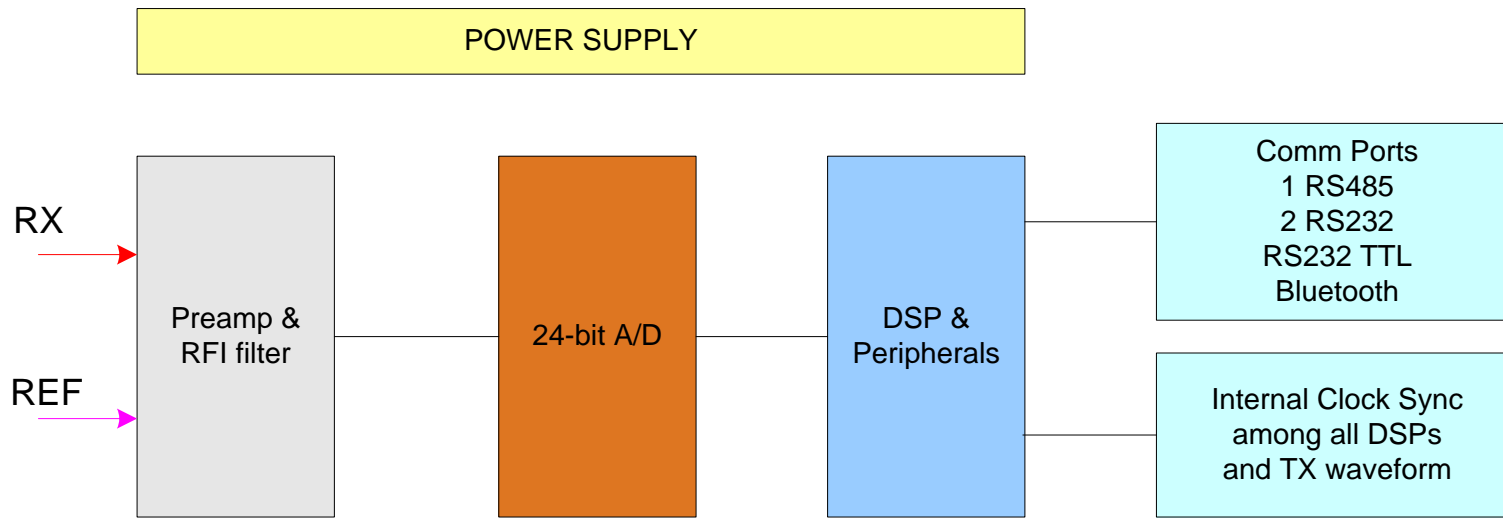
Coil diameters:  
 RX = 12.5 cm for all  
 TX2-0: 24.15 cm  
 TX2-1: 24.00  
 TX2-2: 23.4  
 TX2-3: 18.05

TX1/TX2 Turn Ratio: 4:1  
 Dipole Loss: 4.7%

## GEM-3 Array Example

# GEM-3 Array Electronic Block Diagram





Basic module for each receiver channel

Geophex's multi-channel transmitter and receiver electronics

## Receiver Block Diagram

For each transmitted frequency, the DSP performs real-time Fourier transform:  
*Sine* convolution – inphase (I), and  
*Cosine* convolution - quadrature (Q)

I & Q are the basic raw data



## Data Collection Sequence

Once for survey: Operator enters frequencies (typ. 10-12) and other desired parameters  
DSP builds the current waveform– “bit stream command”

The following repeats every base period (typ. 1/30 sec):

Transmitter (TX) sends out the current waveform for 1 base period  
Switching rate at 384 kHz – 12,800 switching steps (=384000/30)

Receiver (RX) digitizes voltages from both RX and reference (Ref) coils:  
ADC at 24bits/192 kHz – 6,400-point long time-series for RX & Ref

1. DSP performs discrete Fourier transform to the time-series for RX and Ref  
Sine transform – inphase (I) data  
Cosine transform – quadrature (Q) data
2. Normalize against Ref-coil output at each frequency:

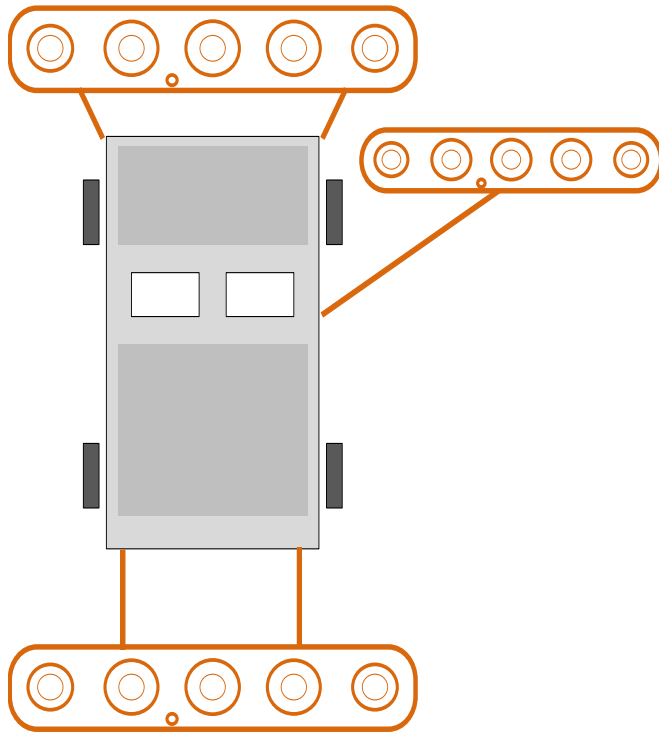
$$\text{Raw ppm data} = \frac{\text{RX } (I + iQ): \text{Target Response}}{\text{Ref } (I + iQ): \text{Primary Field strength}} \times 10^6$$

3. Merge the raw ppm data with GPS and other data
4. Plot data on the screen; archive the data; etc.



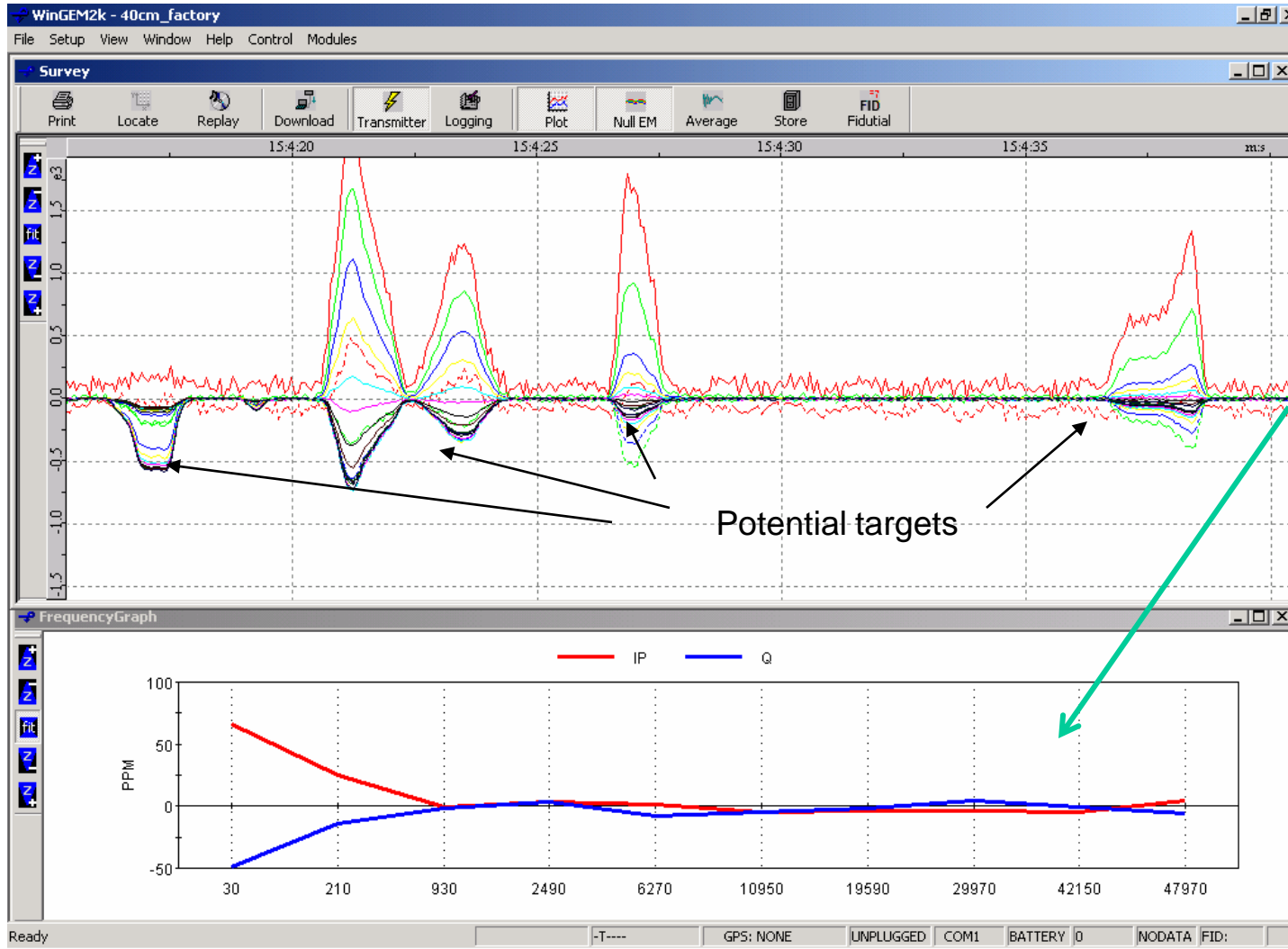
1/30 sec

# Vehicular Deployment Issue



The GEM-3 array can be constructed in any desired swath with up to 16 channels of individual receivers. It can be built as a flat panel or in skeletal ribs to save weight, which would be light enough to be front- or even side-mounted to a vehicle

# Multi-frequency Data Display in Real Time



Single-channel  
multi-frequency  
data in time

Potential targets

Instantaneous  
spectrum

# Target Detection

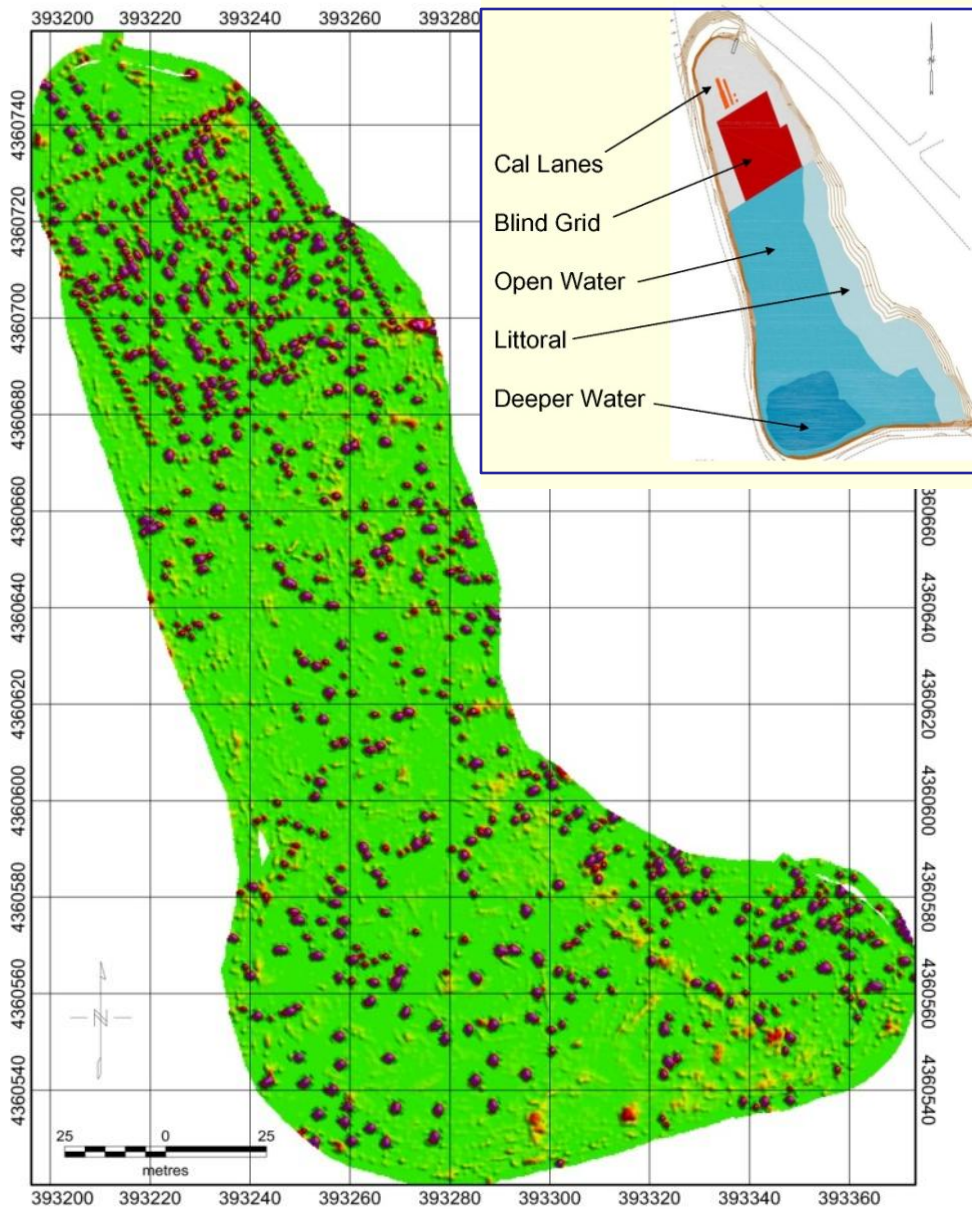
What *detection signal* do we have out of the 10-frequency data from each channel?

**Q-Sum:** Sum of all Q responses - insensitive to magnetic geology, weakly sensitive to conductive geology

**Q- or I-Spread:** Sum of absolute differences among all chosen frequencies - best at suppressing geologic noise

**Apparent Conductivity:** Non-linear transformation tends to bring out weaker anomalies (small or deep UXO)

**Apparent Susceptibility:** Ferrous UXO only - EMI sensor as a magnetometer



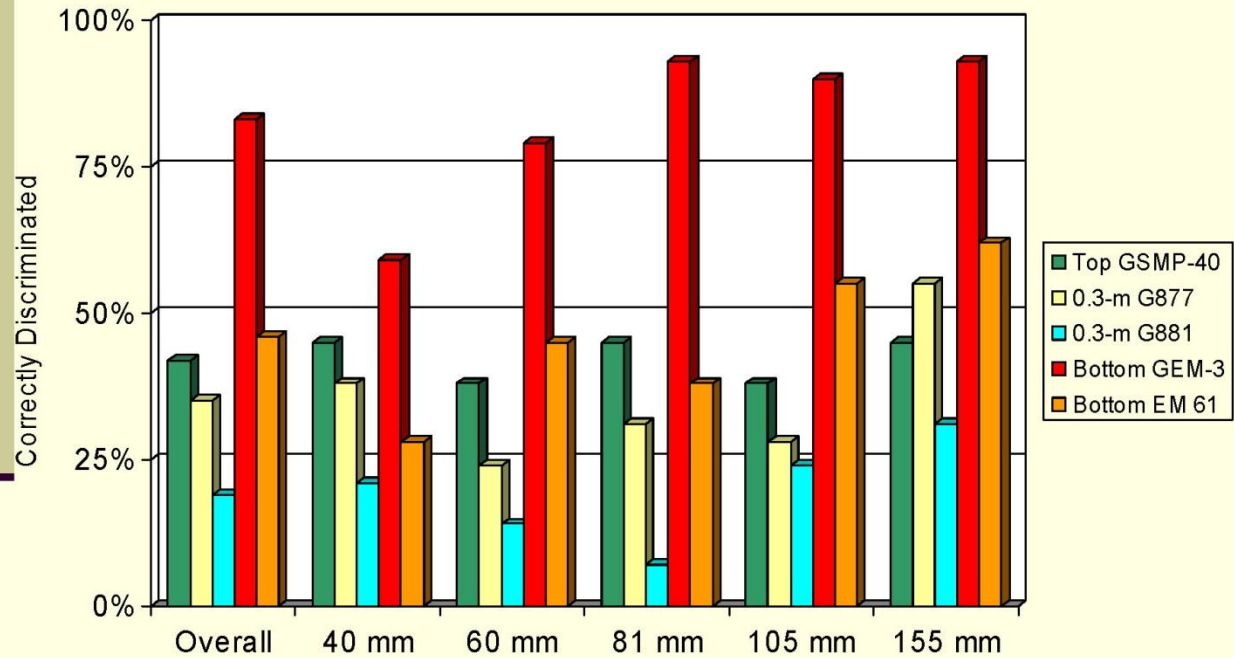
Underwater GEM-3 Array Data  
From APG, Maryland (2005)



Charts reproduced from  
 “MEC Detection in Shallow  
 Water” by Gary Rowe of the  
 Army Testing Center in APG

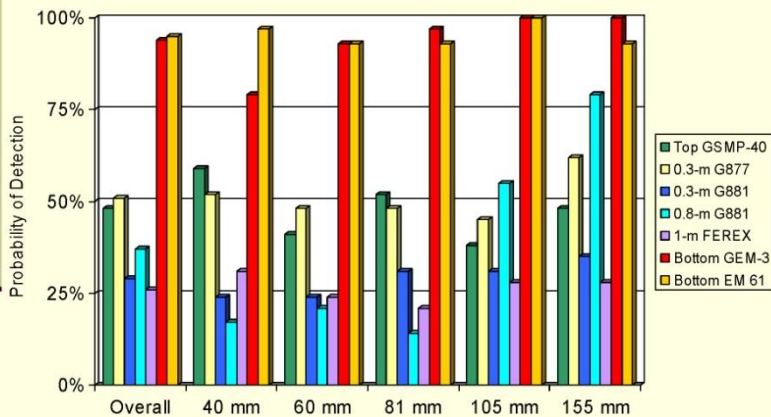
UXO Forum 2006 in Las Vegas

# Discrimination Stage



Discriminate data was not provided by ERDC and CTC-Forester.

# Response Stage



# Locating a target using dual GPS

