Geophysical Classification Field Demonstration

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Geophysical Classification Field Demonstration

- Dan Steinhurst, NRL
  - Data Analysis
- Glenn Harbaugh, NRL
  - Data Collection
- TEMTADS MP 2x2 Cart
  - Developed at NRL

Photo courtesy AECOM

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- Today's speakers are Dan Steinhurst and Glenn Harbaugh from the US Naval Research Laboratory (NRL)
- The field demonstration will feature an "advanced EMI sensor platform," the NRL TEMTADS MP 2x2 Cart

Demonstration Outline

- **DATA ANALYSIS** procedures for Survey Data (DYNAMIC)
  - Anomaly detection
  - Advanced anomaly detection
  - INSIDE
- **DATA COLLECTION** procedures for Static Data (CUED)
  - Hands-on demonstration
  - OUTSIDE!
- **DATA ANALYSIS** procedures for Static Data (CUED)
  - Extraction of high-fidelity parameters for classification
  - INSIDE

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- Inside demonstration of dynamic analysis
- Outdoor demonstration of cued data collect
- Audience participation encouraged for outside portion
- Back inside for demonstration of cued data analysis

NRL TEMTADS MP 2x2 Cart

Photo courtesy Daniel Steinhurst, NRL

- **Advanced EMI Sensor System**
- **Man-portable, designed for rugged terrain**
- **Up to 1 ACRE/DAY survey mode**
- **≤ 250 ANOMALIES/DAY static mode**

Photo courtesy Leidos Corporation

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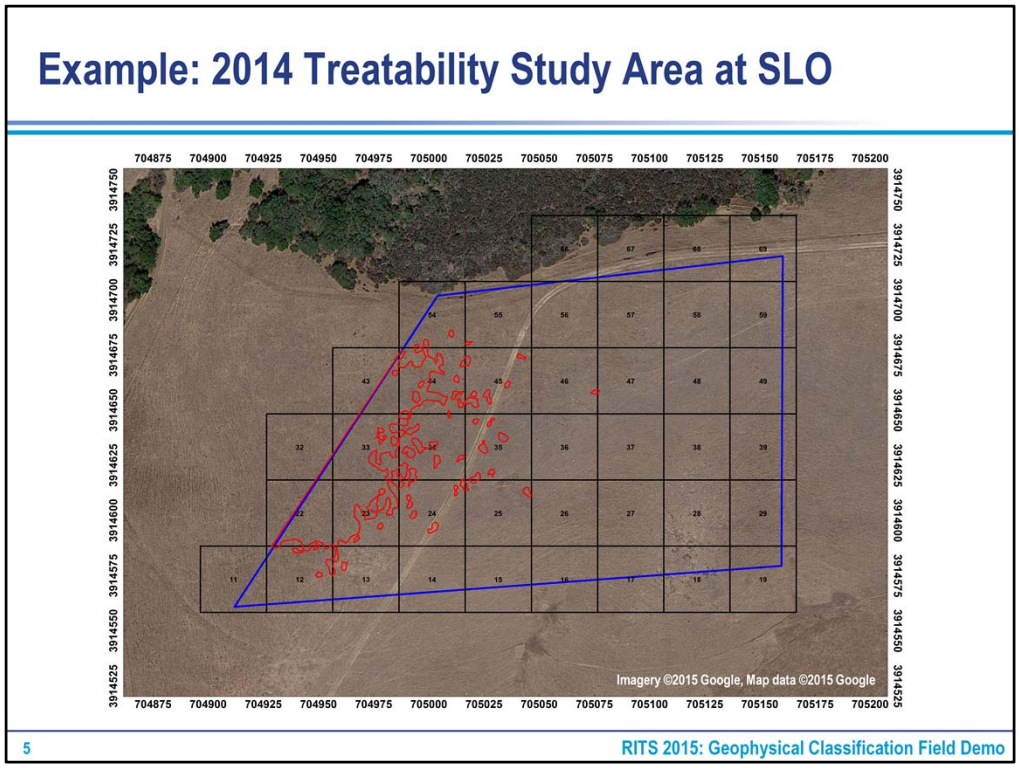
- The system was developed at NRL
- The system is based on similar technologies to those used in the Geometrics MetalMapper, NAVEODTECDIV AOL2, and the CRREL MPV2.
- 2x2 array of TEMTADS/3D sensors, Tx 35cm square, Rx cube 8cm
- Operates at 2.78, 8.32, and 25,0 ms decay times



- 2014 Treatability Study Area at former Camp San Luis Obispo, CA
- Aerial photo, polygon (blue), grids, high density areas (red)

2014 Treatability Study Area - Grid 27

- Focus on a single grid, but in greater detail
- How is dynamic data collected?
- What are the data products?

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- Aerial photograph of Grid 27

Grid 27 – Sensor Path

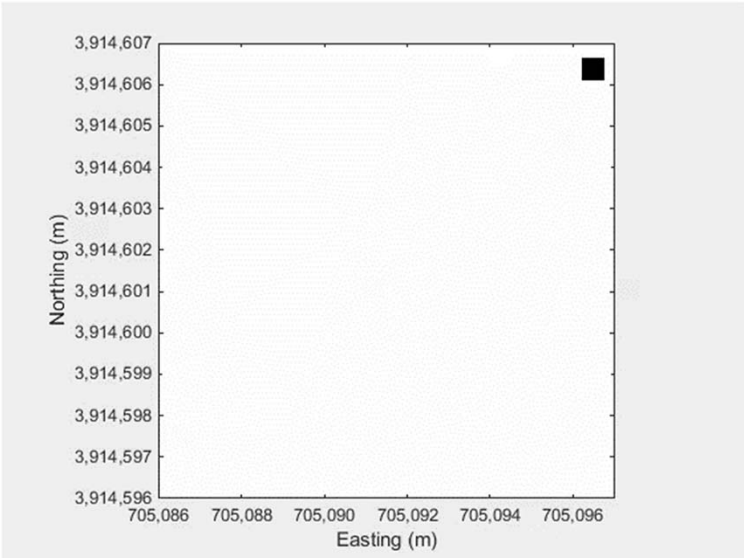
- Team moves sensor across grid in a series of closely-spaced survey lines to build up a dense set of data completely covering the grid
- This method is also called "mowing the grass"

- Array path, path covered by the GPS antenna centered over the array

Mowing the Grass

- This animation shows how "mowing the grass" looks

Note: Time is accelerated



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- Mowing the Grass video

Grid 27 – Sensor Data

- The array location does not completely describe the location of the sensors when each data point is collected
- GPS position and inertial measurement unit (IMU) orientation are used to mathematically calculate the sensor locations

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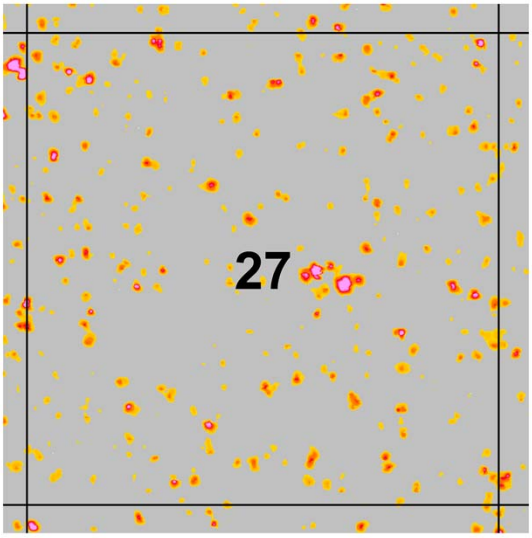
- Located sensor data. Position information, orientation information, and geometry used to determine the position of each sensor for each data point
- Darker edges include data collected for neighboring grids

Grid 27 – Monostatic Z Data

Mapped EMI Data

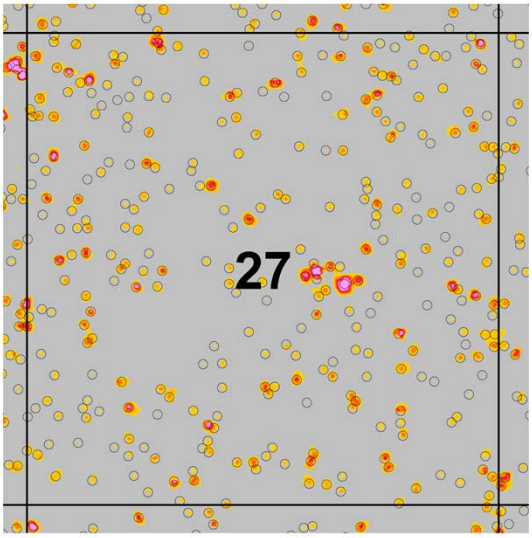
- Values above a threshold color coded
- Threshold is selected to correspond to the expected response of site TOI



- Monostatic Z values most closely reproduce the familiar data products from the EM61-MKII
- Gate at 0.137 ms, threshold 1.7 mV/A. Threshold for a horizontal 37mm projectile buried at 30 cm

Grid 27 – Amplitude-Based Picking

- Anomalies with peak signal amplitudes above the threshold circled
- Threshold for a horizontal 37mm projectile buried at 30 cm is 1.7 mV/A

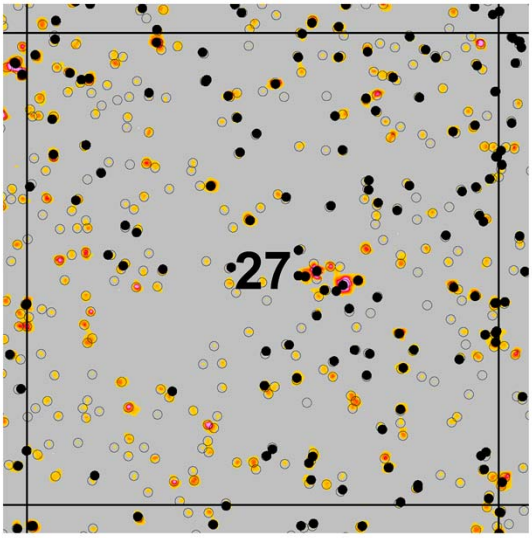


- Monostatic Z values most closely reproduce the familiar data products from the EM61-MKII
- Gate at 0.137 ms, threshold 1.7 mV/A. Threshold for a horizontal 37mm projectile buried at 30 cm

Grid 27 – Dipole-Filter Picking

- More information available that is used by a threshold technique
- Another approach is to use a model to screen the survey data for items that could be TOI
- Selections from dipole filter in black

SIGNIFICANTLY FEWER PICKS!

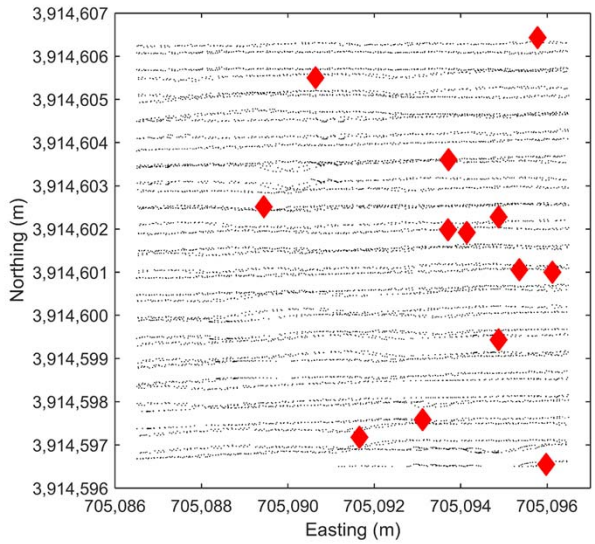


- Dipole filter example
- Threshold for a horizontal 37mm projectile buried at 30 cm
- Anomaly-based picks – 17,093
- Dipole filter picks – 5,739

Grid 27 – Lawn Mowing Example

- Returning to our earlier lawn mowing example
- 13 anomalies might represent TOI
- Highlighted in red
- Data for ~50% of the anomalies may be good enough to classify

DONE WITH THEM!



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- Once the locations of the anomalies are determined, fit parameters can be extracted from the dynamic data for some fraction (~50%) of the anomalies
- These anomalies can then be classified

- Dipole filter picks in red diamonds
- Do we want a movie?

Cued Data Collection

- For rest, higher-fidelity data is required
- The system is placed over each anomaly in turn and additional data is collected

TIME TO GO OUTSIDE!

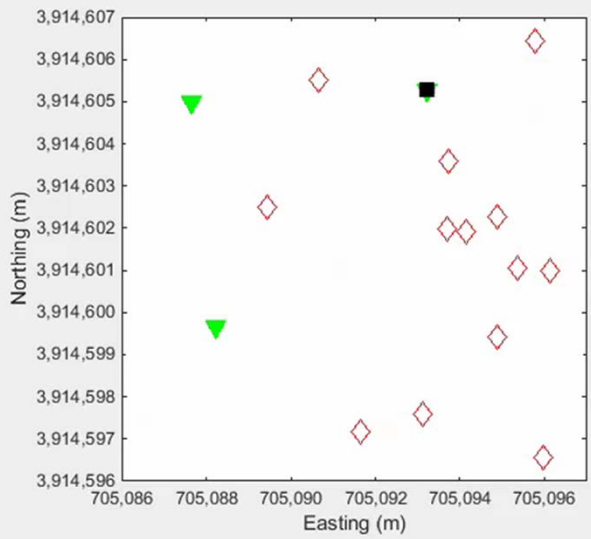
Photo courtesy Daniel Steinhurst, NRL

- For the remainder, a second look in cued mode is required

Cued Data Collection – The Movie

- This animation shows schematically how cued data collection is done

Note: Time is accelerated



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- Video schematic of cued data collection

Cued Data Analysis

- Cued data analysis has three components
  - QUALITY CONTROL (QC) of incoming data
  - Preprocessing incoming data
  - MODELING of anomaly source parameters from data
- At the end of this process, the anomaly source parameters can be used for making UXO / Clutter classification decisions
  - A subject for another day!

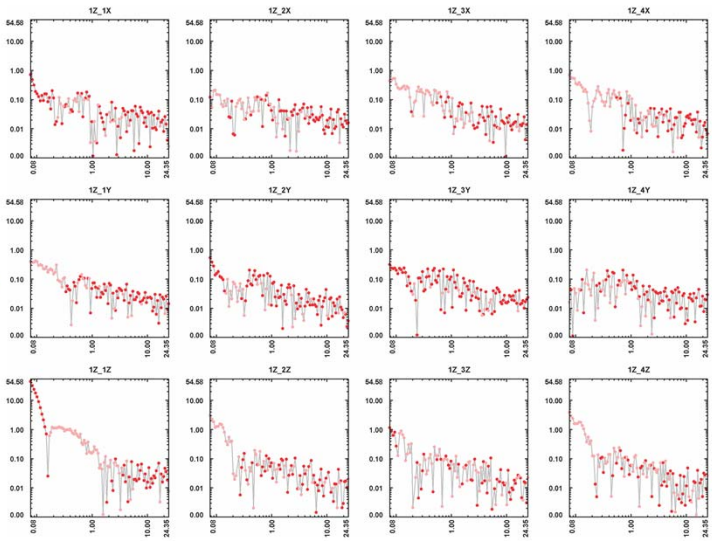
Cued Data Analysis – Backgrounds

- These sensors are sensitive to several phenomena which cause a measureable BACKGROUND response, which must be subtracted from anomaly data
  - Excitation from transmitter pulse
  - Electrical behavior of the coils
  - Moisture
  - GEOLOGY
- To solve this, frequent BACKGROUND measurements are made in known-clear spots near the survey area throughout each day

- Changing geology and weather make frequent backgrounds necessary

Cued Data Analysis – Backgrounds

- Each transmitter fires in sequence
- All 12 receiver channels are recorded for each transmitter fire event



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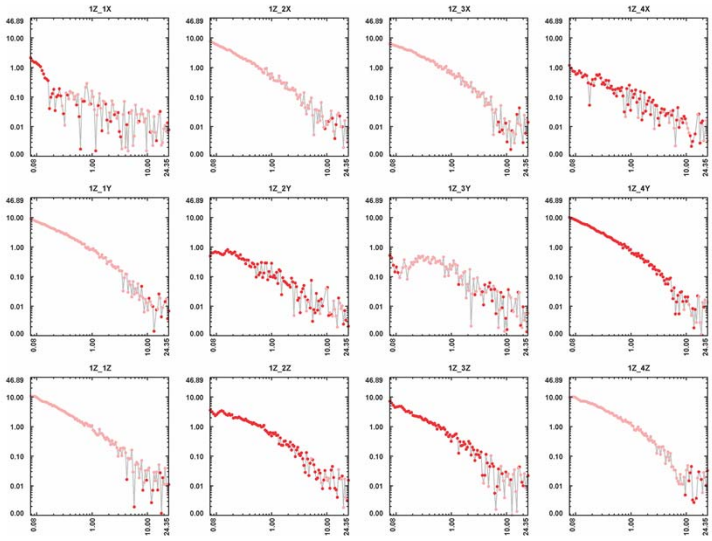
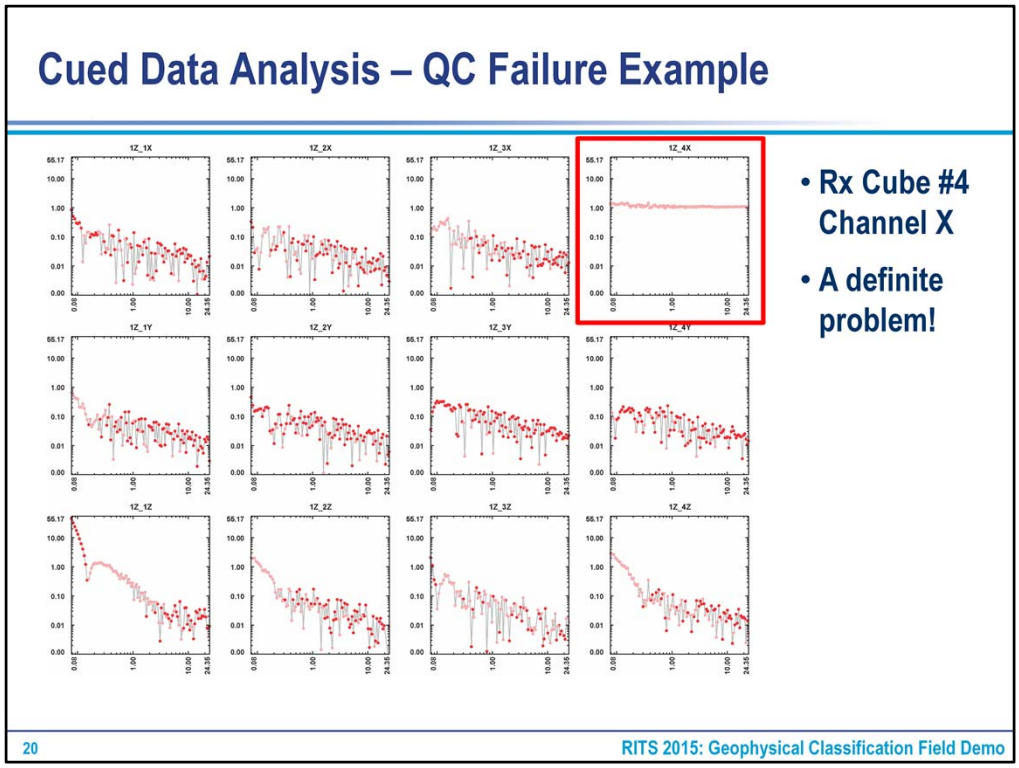
- Only the data from Tx1 firing is shown. Similar results are seen for the other three transmitters firing and listening on all 12 receiver channels.
- Bright red dots are positive signal, light red dots are negative signal.

Cued Data Analysis – QC "leveled" data

- Data clearly contains a LARGE-AMPLITUDE signal
- NO OBVIOUS QC ISSUES
- Ready to move on to modeling the data

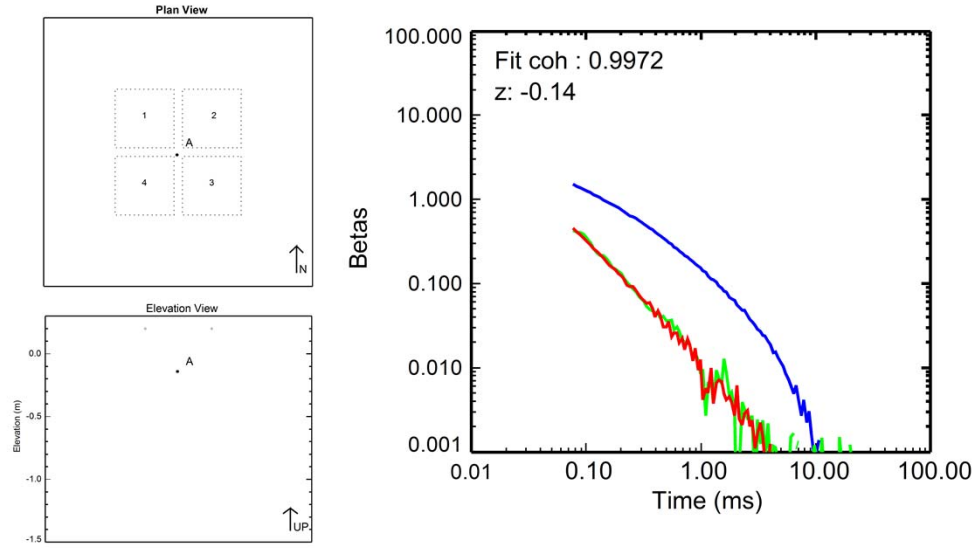


- Leveled = Background subtracted
- Only the data from Tx1 firing is shown
- Similar results are seen for the other three transmitters firing and listening on all 12 receiver channels
- Bright red dots are positive signal, light red dots are negative signal

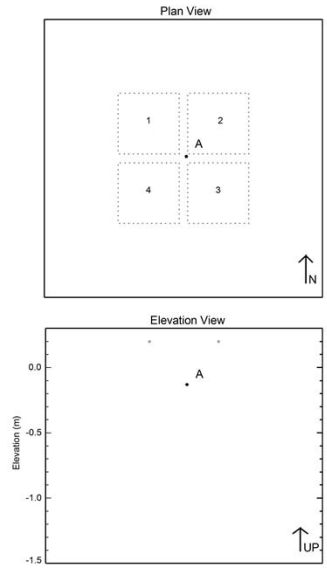


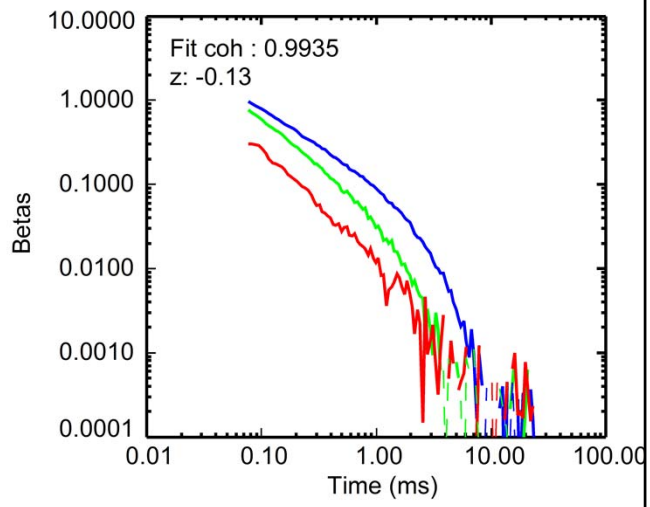
- Tx1_Rx4X – for some reason the recorded transient never returned to zero
- Not seen again that day
- Potentially an external source?

Fit Results – Small ISO80

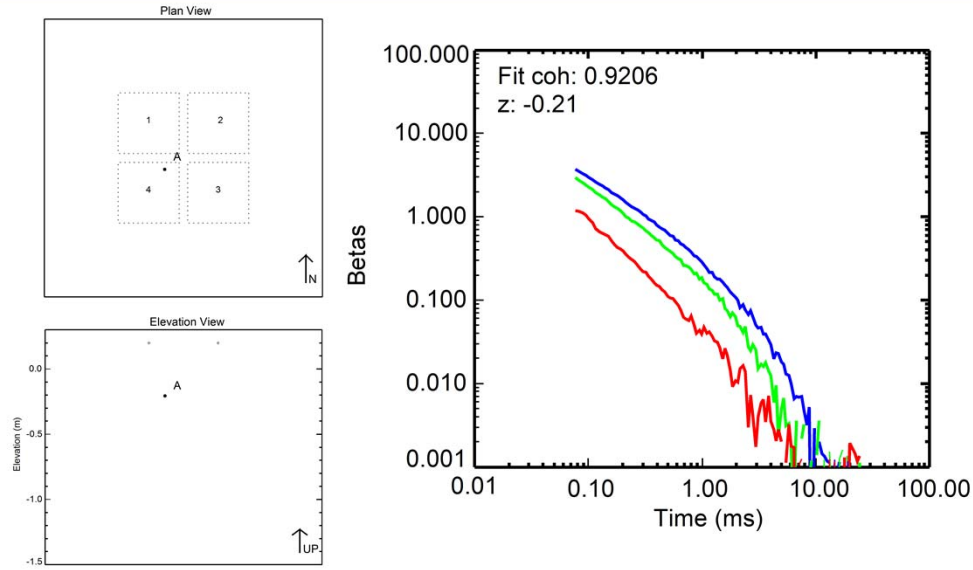
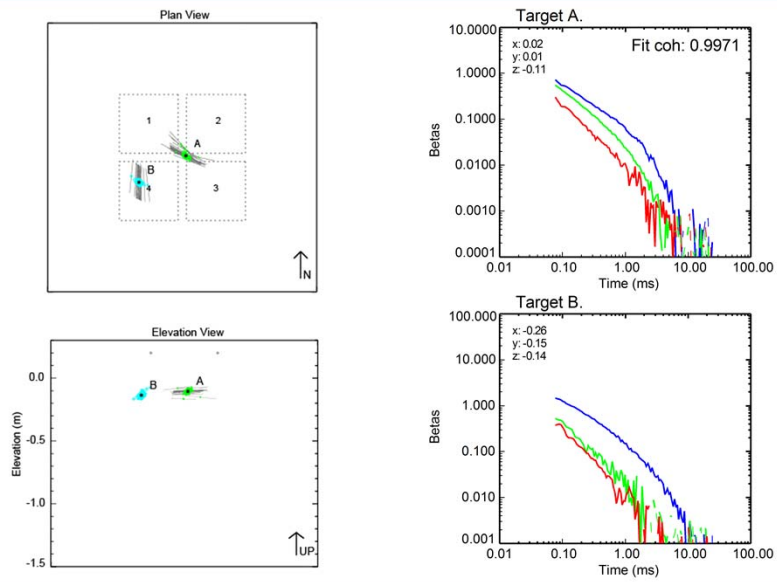


Fit Results – Piece of Range Scrap





Single-Object Solver – Small ISO80 and Scrap



Multi-Source Solver– Small ISO80 and Scrap