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Quality Management for Advanced Classification

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Goals of Presentation

➢ Define Quality Management, Quality Assurance, and Quality Control in the context of Advanced Classification

➢ Present current 'state of the art' with examples

➢ Discuss direction of current development and associated challenges.
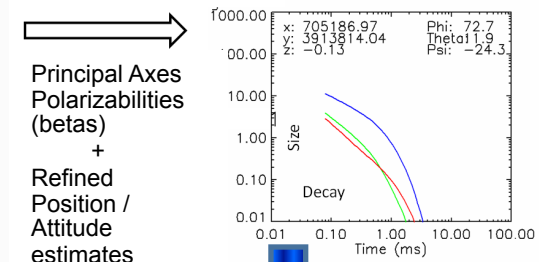
Advanced Classification:

➢ **Data Acquisition**
New sensors provide a rich data set of observed responses.
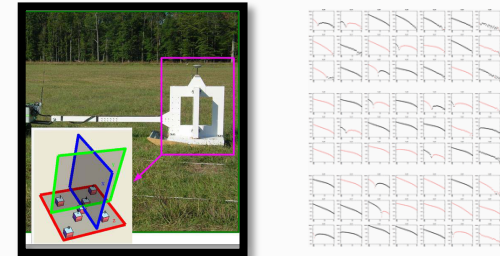
➢ **Modeling**
What combination of features (size, shape, composition, location and orientation) would provide responses that match the observed responses?

➢ **Classification**
Do the intrinsic features (size, shape, composition) look like an ordnance item?

Principal Axes
Polarizabilities
(betas)
+
Refined
Position /
Attitude
estimates

x: 705186.97   Phi: 72.7
y: 3913814.04   Theta11.9
z: −0.13   Psi: −24.3

Size

Decay

Time (ms)

Rank	Comment
1	High confidence munition
2	
3	
…	Can't make a decision
…	
…	High confidence non-munition
…	
…	
…	
…	
N	

Quality Management Objectives

➢ Ensure the quality of the data being collected

➢ Ensure that the collected data and derived products support conclusions based upon these results

➢ Document the QC/QA findings so that the client can be assured of the quality of the results

"I THINK YOU SHOULD BE MORE EXPLICIT HERE IN STEP TWO."
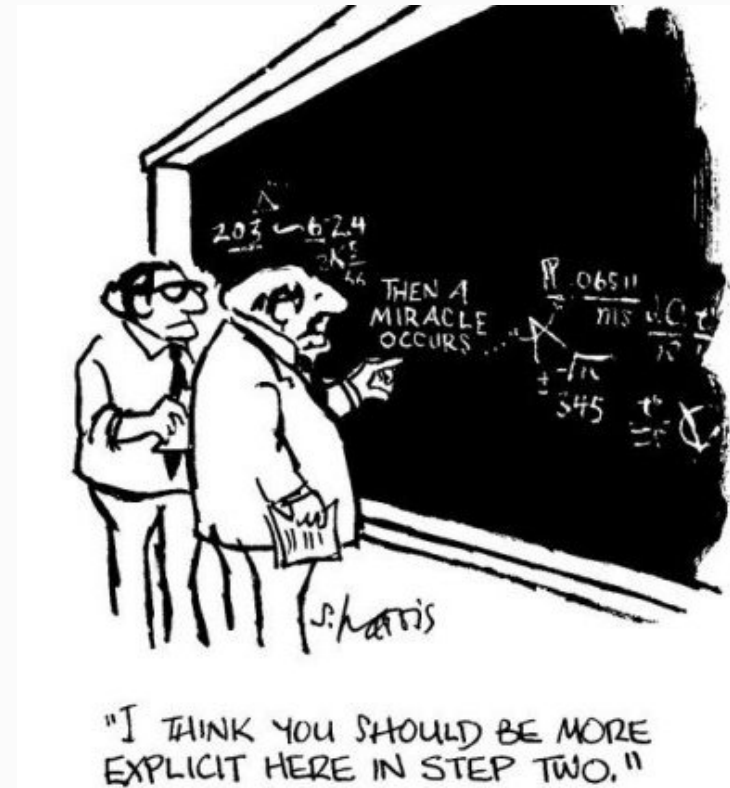
Quality Management
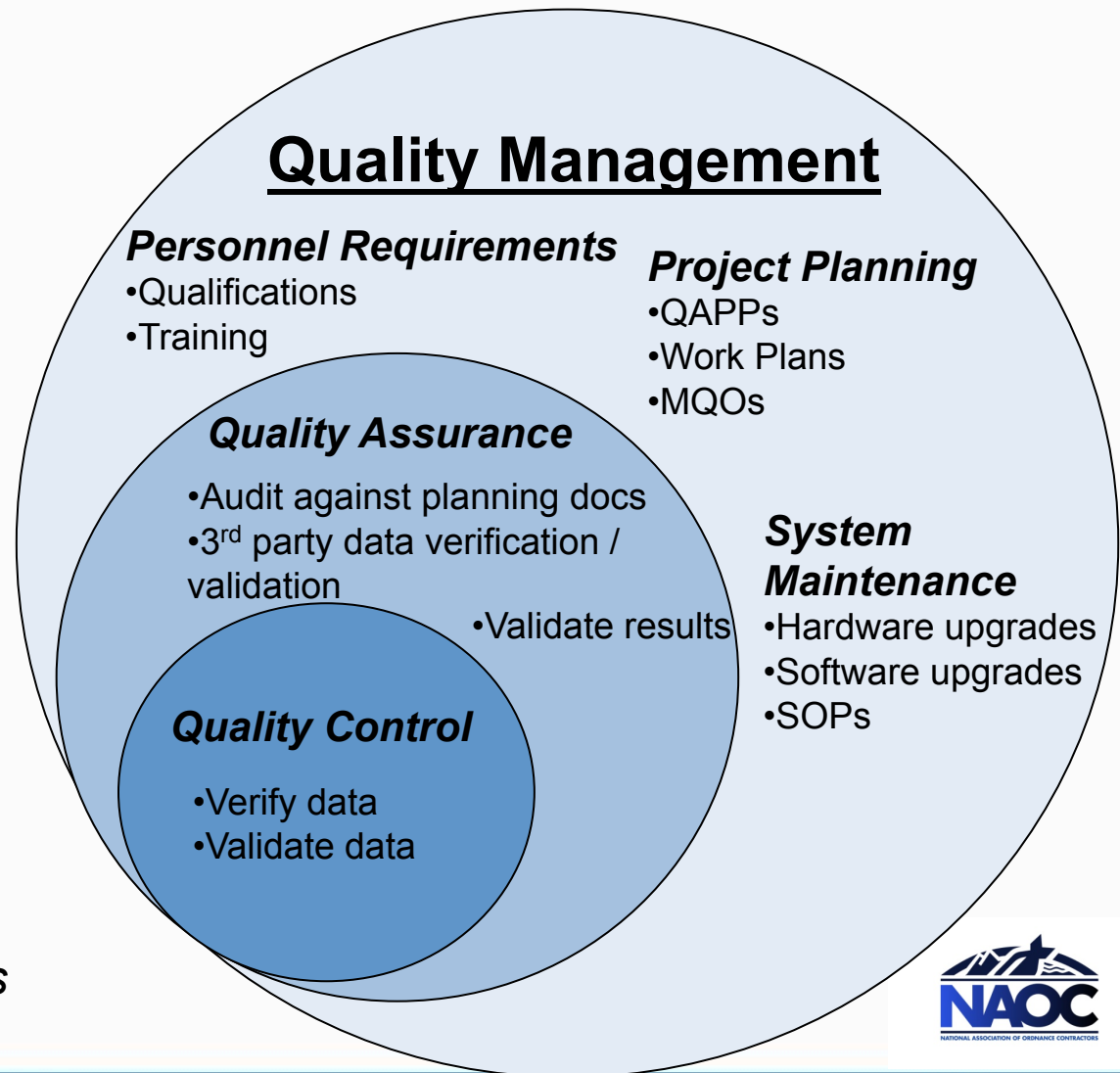
Quality Management:

Program activities involved with all aspects of quality

Quality Assurance:

Audit project activities against planning documents

Quality Control:

Audit project data against planned or standard measurement quality objectives

Quality Management

Personnel Requirements
- Qualifications
- Training

Project Planning
- QAPPs
- Work Plans
- MQOs

Quality Assurance
- Audit against planning docs
- 3rd party data verification / validation
- Validate results

System Maintenance
- Hardware upgrades
- Software upgrades
- SOPs

Quality Control
- Verify data
- Validate data

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Quality Control

➢ **Data Acquisition**

- Cued measurements

- Dynamic measurements

➢ **Data Modeling**

- Single-target or multi-target inversion to find model(s) that best fit observed data

- Output = features intrinsic to the target

➢ **Classification**

- Use features to sort targets into a 'prioritized list'

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Advanced Sensors

Sensor	Tx/ target orientation	Tx/ Rx combinations	Time gates	Data pts/ cued target
EM61 Mk2	Dynamic*	Single	4	324*
TEMTADS 2x2	Dynamic	4 Tx x 12 Rx = 48	100	4,800
MetalMapper	Dynamic	3 Tx x 21 Rx = 63	40	2,500

* requires multiple positions (9x9 pt sample grid)

Sensor Function QC

TEMTADS 2x2 Function Test
New Boston AFS (Cued)
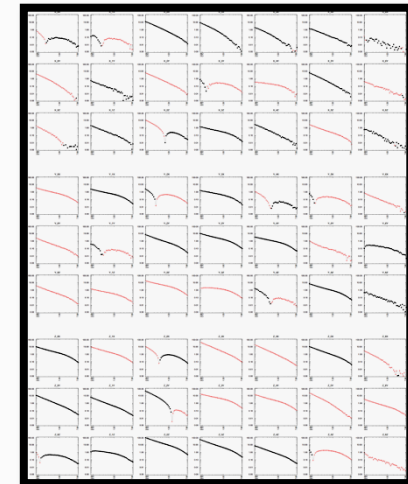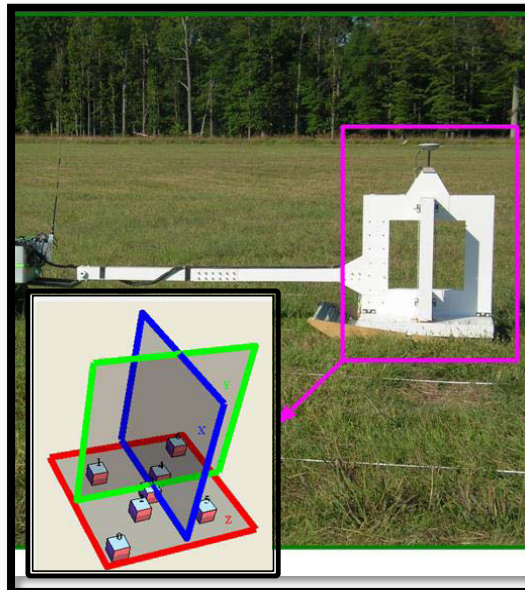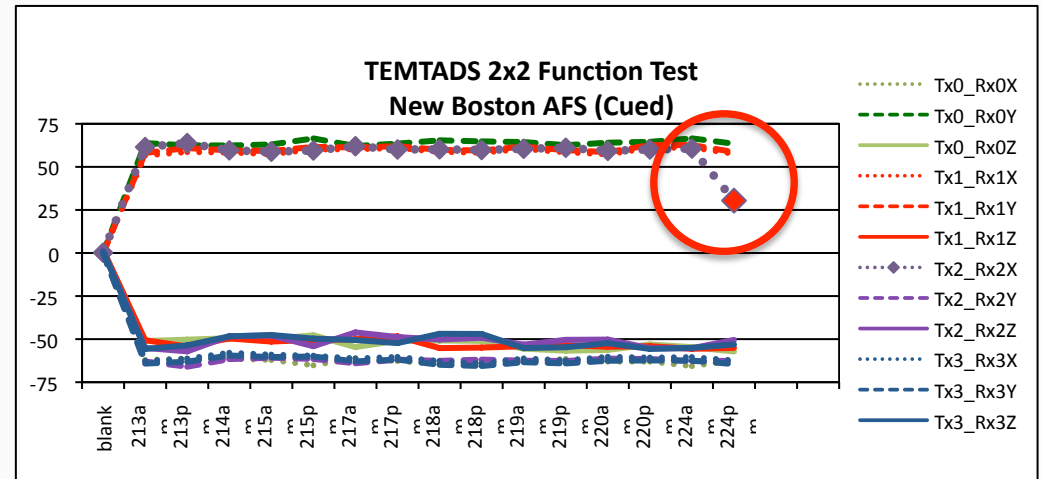
➤ QC reports should be:

- Easy to generate on a daily basis
- Designed to identify problems in a timely manner
- Standardized for easy interpretation and evaluation

Background Removal QC
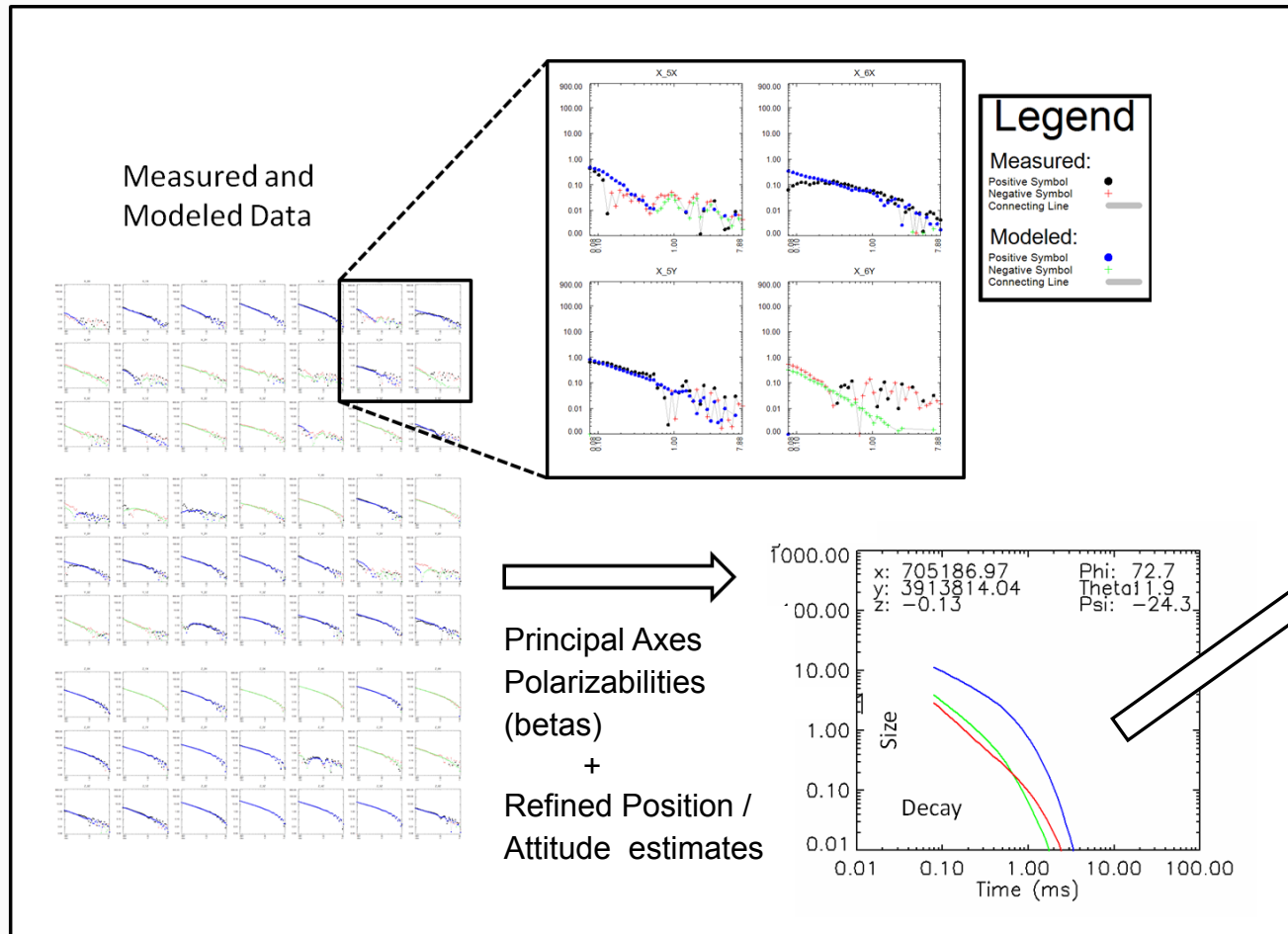
➢ Background corrections applied to remove:

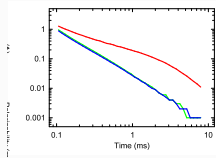   1. Soil response
    2. 'Zero level' drift
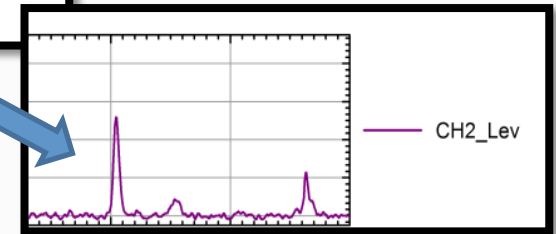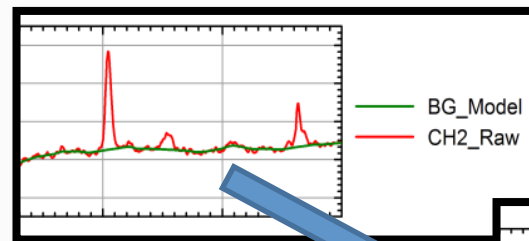
➢ Therefore background measurements must:

    1. Be taken in similar soils to that of the target (minimize the spatial offset)
    2. Be taken frequently (minimize temporal offset)
    3. Be free of signal due to metal sources

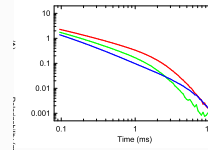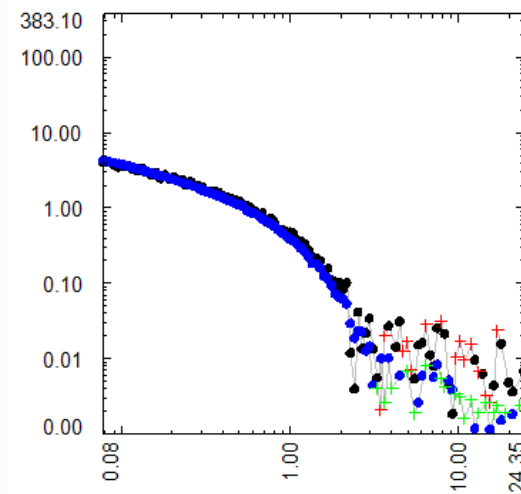# Data Modeling

Data Modeling QC

≈ ?

 ≈ ?

➢ The intrinsic parameters are representative of the target if:

  1. The modeled data match the observed data

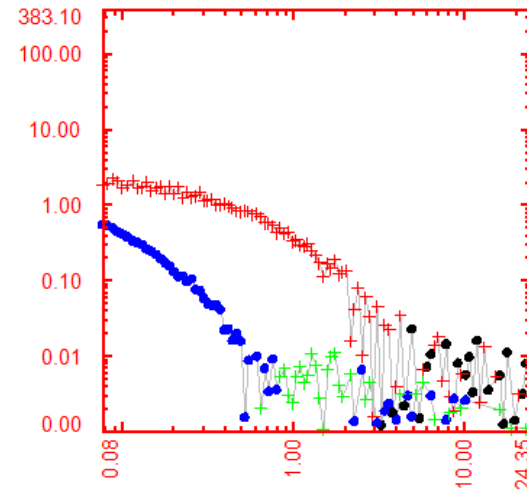 2. The target was energized along all three principal axes

Data Modeling QC

➢ "Fit coherence" metric indicates how well the model fits the observed data
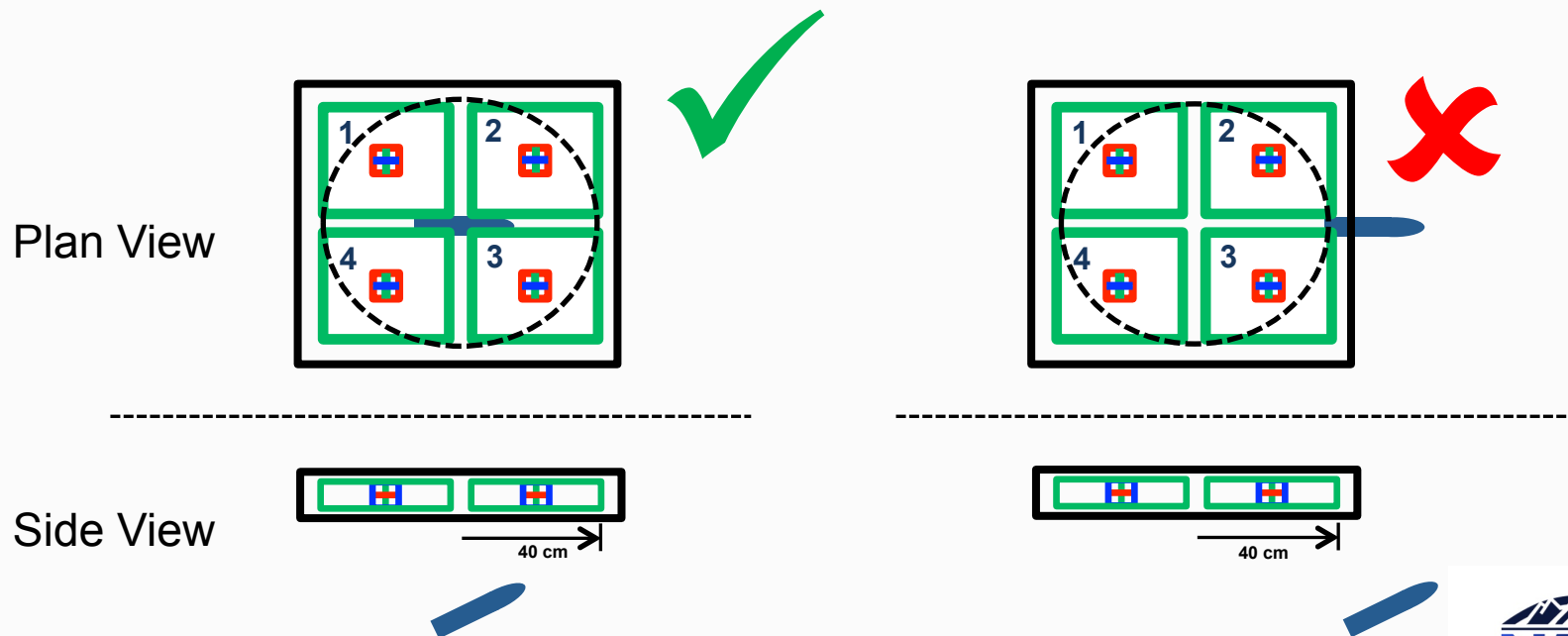

Measured:
Positive Symbol ●
Negative Symbol +

Modeled:
Positive Symbol ●
Negative Symbol +

Data Modeling QC

➢ Targets outside of the 'sweet spot' may not have been energized along all three axes

➢ Fit position offset > 40 cm indicate the results may be unreliable

Plan View

Side View

40 cm

40 cm

Classification

➢ Library matching is the primary approach to classification, but there is some variability in how it is implemented:

81mm mortar complete
metric_3critTOI - 0.9419
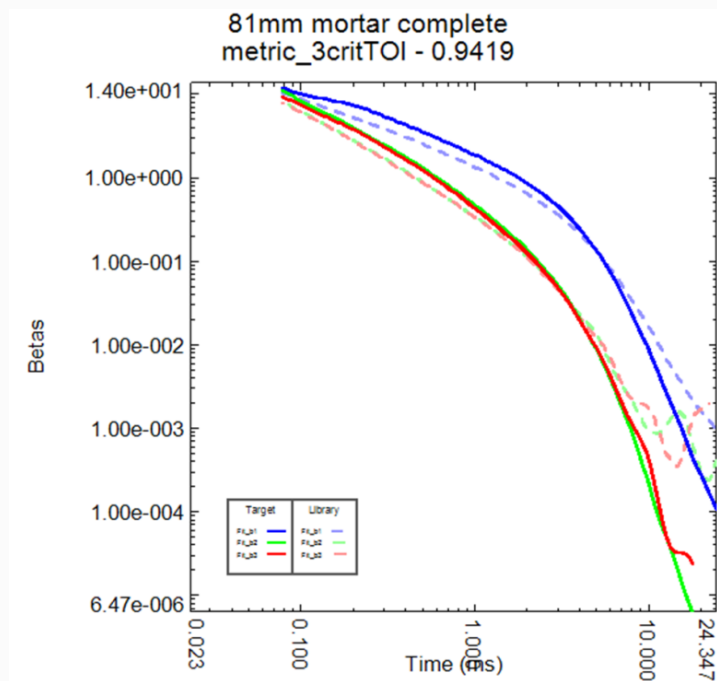
➢ 'Man-in-the-loop' decisions are made on difficult targets – more experience = greater success

➢ What is more important to the client, performance or transparency ?

Quality Management

- ➤ **Personnel Requirements**
  - ▪ Training
  - ▪ Experience
- ➤ **Project Planning**
  - ▪ QAPPs
  - ▪ Site considerations
- ➤ **System Maintenance**
  - ▪ Hardware software upgrades
  - ▪ SOPs

Quality Management

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Quality Control
- •Verify data
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Project Planning
Quality Assurance Project Plan (QAPP)

➢ QAPP:
  "a formal document describing in comprehensive detail the necessary quality assurance (QA), quality control (QC), and other technical activities that must be implemented to ensure that the results of the work performed will satisfy the stated performance criteria" – EPA web site
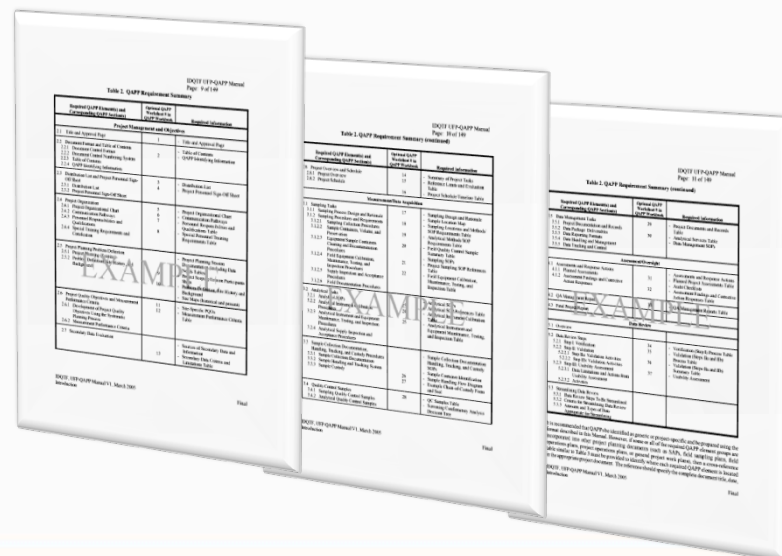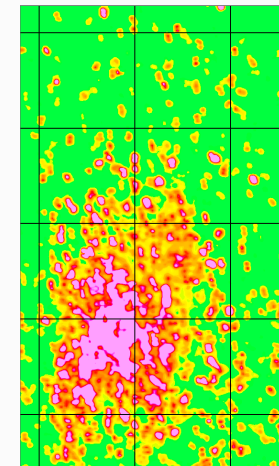
Project Planning: Site Considerations

Pole Mtn (resistive) Beale (conductive)

➢ Soil composition / geology
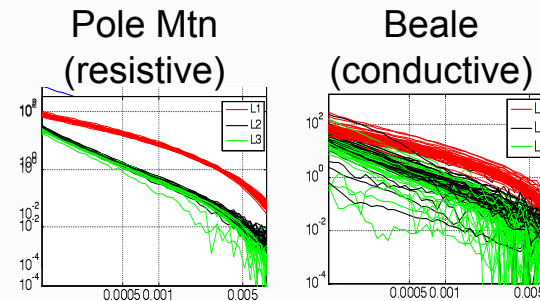
➢ Types and variability of anticipated TOI's, % of TOI

➢ Density distribution of metal

➢ **Pilot Studies/Cost Benefit Analyses to manage expectations**

System Maintenance

- Sensor redesign/upgrades

  - Data format moving to Hierarchical Data Format (HDF)5.

  - Field-worthiness improvements

- Software upgrades

  - Take advantage of HDF5 format

  - Streamlining to create a 'standard' workflow

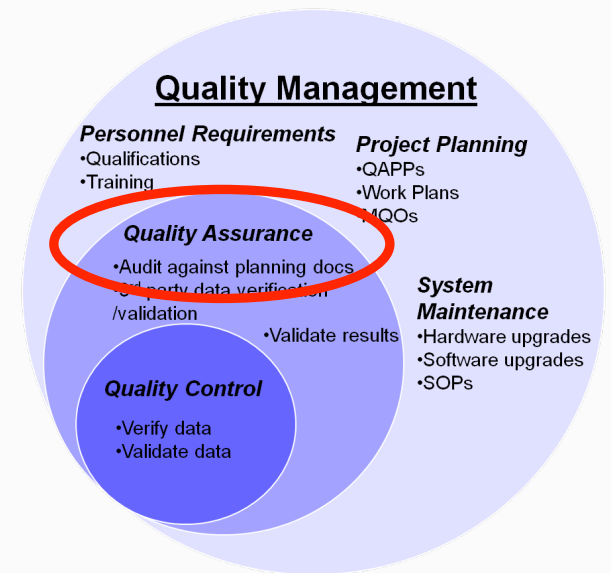 - Emphasis on QC tools

Standard Operating Procedures

1	Assemble the MetalMapper System and Verify Correct Operation
2	Test Sensor and System at the IVS
3	Production Area Seeding
4	Collect Dynamic Data Using the MetalMapper Sensor
5	Preprocess Dynamic Data and Identify Anomalies
6	Collect Static Background Measurements
7	Collect Cued Target Measurements
8	Verify Usability of Advanced Sensor Data
9	Background Correct Cued Anomaly Data
10	Invert anomaly data to extract source parameters
11	Compare extracted parameters to MEC signatures in the data library
12	Develop prioritized dig list using library matching and other factors
13	Verify recovered objects are compatible with advanced classification predictions
14	Develop verification sampling dig list and perform verification sampling

Quality Assurance

➢ **Challenges:**

- Library maintenance

- Classification approach

- Operator threshold and validation of results

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TOI Library

➤ Who maintains the Library?

➤ What items are in the library?

➤ How do we handle the risk of unexpected munitions types that are not in the library?

- Cluster analysis
- Large, symmetric, thick-walled objects

Munition Item	Depth (in)	Orientation	Photo	Library_ID
60 mm illumination round	14.0	Horizontal		60 mm illumination round_VQ269001
60 mm illumination round	16.0	Vertical - nose up		60 mm illumination round_VQ269002
60 mm illumination round	16.0	Vertical - nose down		60 mm illumination round_VQ269003
60 mm illumination round	14.0	45° - nose down		60 mm illumination round_VQ269004
4.2" mortar	21.0	Horizontal		4.2" mortar_VQ269005
4.2" mortar	16.0	Vertical - nose up		4.2" mortar_VQ269006
4.2" mortar	22.0	Vertical - nose down		4.2" mortar_VQ269007
4.2" mortar	24.0	45° - nose down		4.2" mortar_VQ269008
3.5" rocket, no nose cone	15.0	Horizontal		3.5" rocket, no nose cone_VQ269009
3.5" rocket, no nose cone	16.0	Vertical - nose up		3.5" rocket, no nose cone_VQ269010
3.5" rocket, no nose cone	13.0	Vertical - nose down		3.5" rocket, no nose cone_VQ269011
3.5" rocket, no nose cone	14.0	45° - nose down		3.5" rocket, no nose cone_VQ269012
3.5" rocket, with nose cone	13.0	Horizontal		3.5" rocket, with nose cone_VQ270001
3.5" rocket, with nose cone	19.0	Vertical - nose up		3.5" rocket, with nose cone_VQ270002
3.5" rocket, with nose cone	20.0	Vertical - nose down		3.5" rocket, with nose cone_VQ270003
90 mm AP with drive band	13.0	Horizontal		90 mm AP with drive band_VQ270004
90 mm AP with drive band	12.0	Vertical - nose up		90 mm AP with drive band_VQ270005
90 mm AP with drive band	11.0	Vertical - nose down		90 mm AP with drive band_VQ270006
90 mm AP with drive band	11.0	45° - nose down		90 mm AP with drive band_VQ270007
2.75" rocket WH	14.0	Horizontal		2.75" rocket WH_VQ270008
2.75" rocket WH	16.0	Vertical - nose up		2.75" rocket WH_VQ270009
2.75" rocket WH	16.0	Vertical - nose down		2.75" rocket WH_VQ270010
2.75" rocket WH	17.0	45° - nose down		2.75" rocket WH_VQ270011
M26 rifle grenade	13.0	Horizontal		M26 rifle grenade_VQ270012
M26 rifle grenade	8.0	Vertical - nose up		M26 rifle grenade_VQ270013
M26 rifle grenade	10.0	Vertical - nose down		M26 rifle grenade_VQ270014
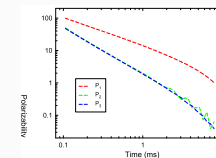
Objective vs Subjective Analysis

➢ Ranking should be performed using *quantitative, objective, defensible* criteria.

Rank	flag_ID	decision_statistic
45	3257	0.9431
46	2279	0.9400
47	2126	0.9387
48	3146	0.9373
49	2591	0.9373
50	2218	0.9372
51	2214	0.9371
52	1918	0.9365
53	3071	0.9365
54	1985	0.9352
55	3404	0.9339
56	2174	0.9337
57	2058	0.9335
58	2536	0.9329
59	2130	0.9323
60	2159	0.9307
61	3312	0.9293
62	2052	0.9293
63	2183	0.9286
64	2176	0.9285
65	3424	0.9275
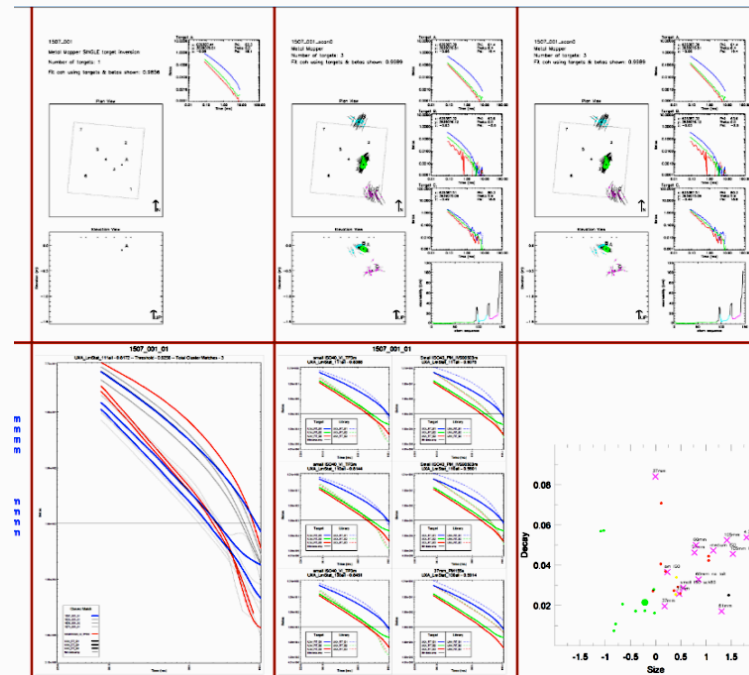
Subjective Decisions?

➢ Subjective decisions to move a target from the 'dig' to 'no-dig' category should be strongly discouraged
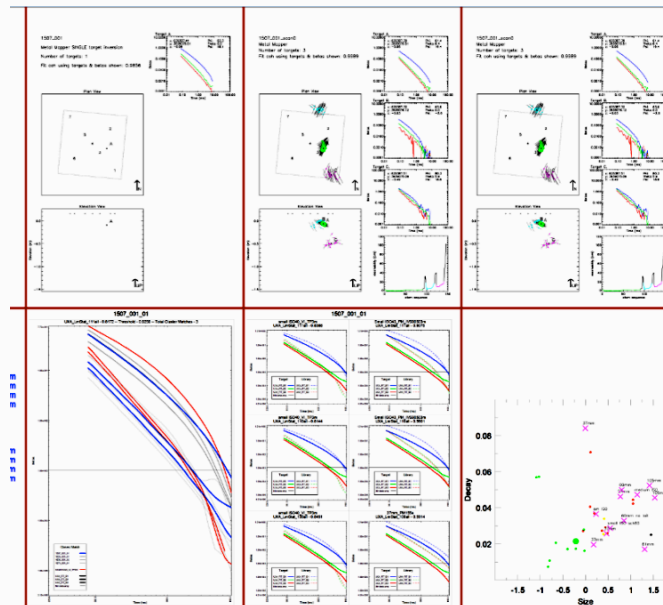
Subjective Decisions?

➢ Subjective decisions to move a target from the 'no-dig' to 'dig' category are consistent with the conservative approach of "if in doubt, dig"
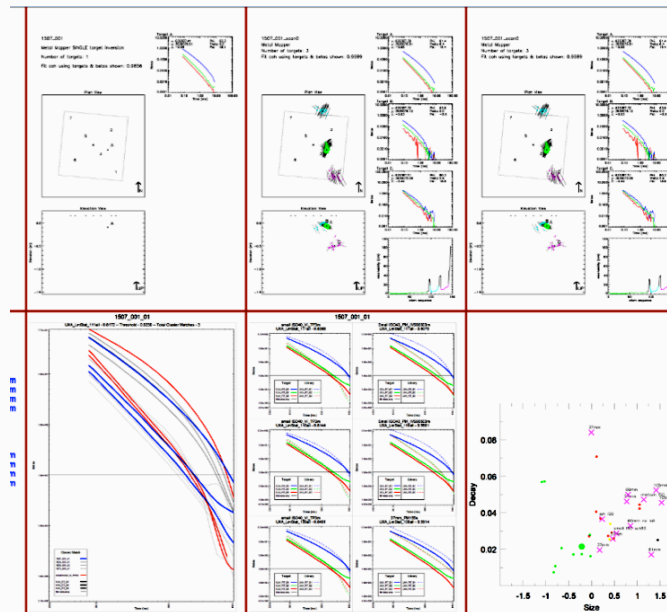
Analysts 'Threshold'

➢ Who should ultimately make the 'stop dig' decision?

- Factors such as remediation budget, end use, exposure pathways are beyond the purview of the analyst.

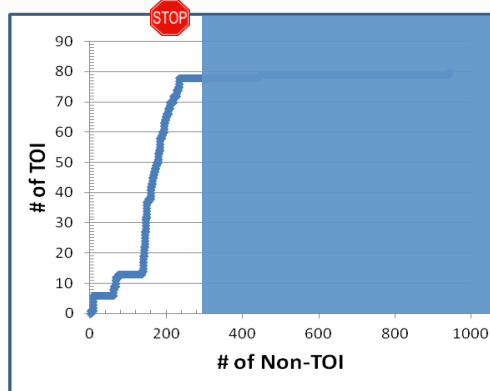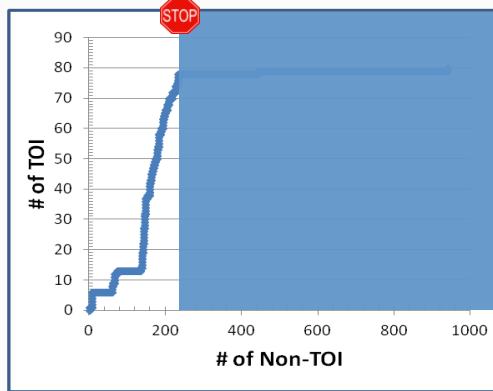| Rank	Comment
1	High confidence munition
2	
3	
…	Can't make a decision
…	
…	High confidence non-munition
…	
…	
…	
…	
…	
…	
N	
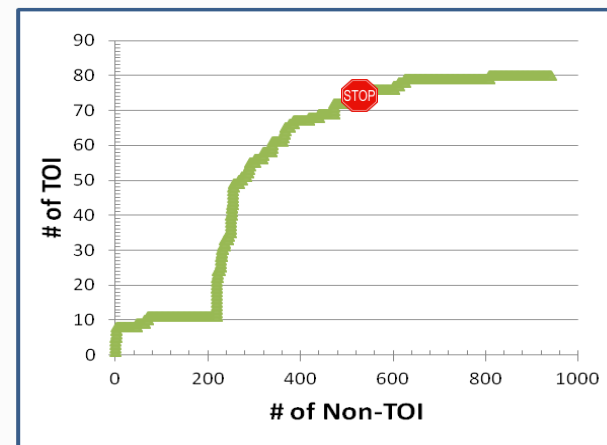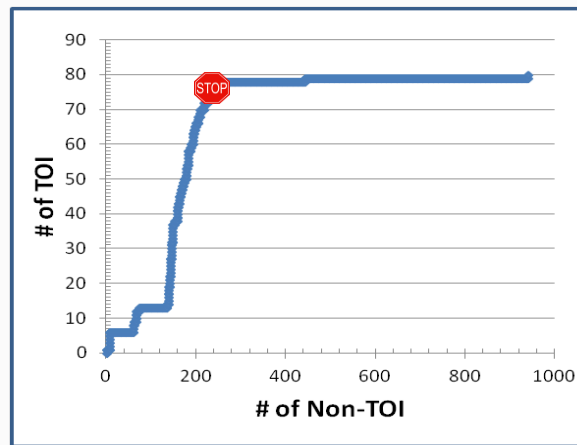
Classification Validation

➤ Can the results act as a QC tool?

Analyst Threshold   +10%   +20%
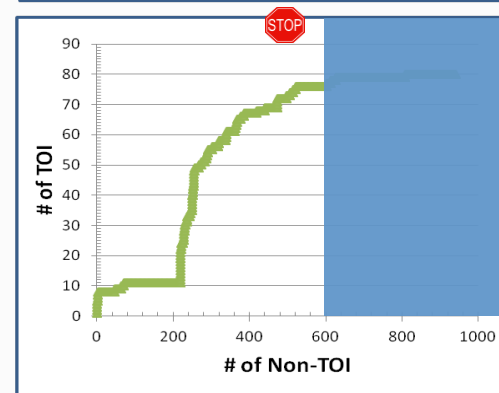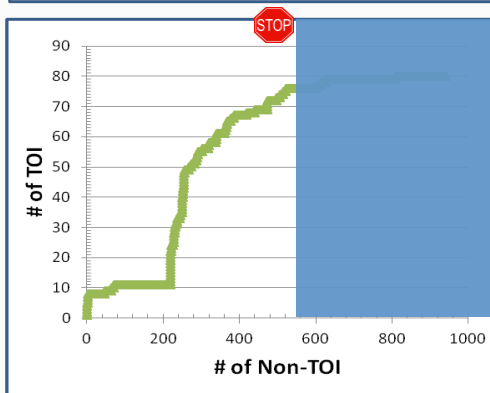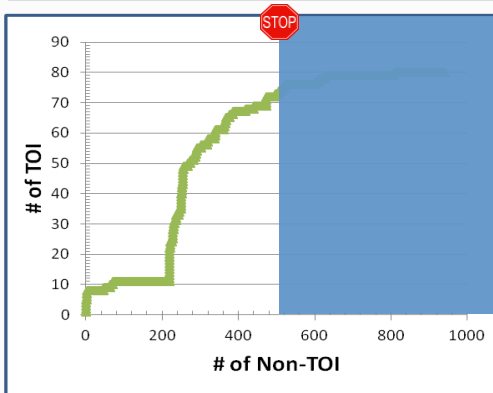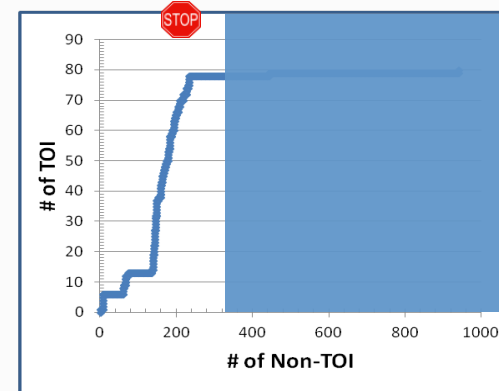
Final Thoughts

➢ Advanced Classification has been shown to provide significant efficiencies in risk reduction at military munitions response sites

➢ Quality Management will be critical to the successful implementation of Advanced Classification

Comments/Questions?

Contact: David Wright
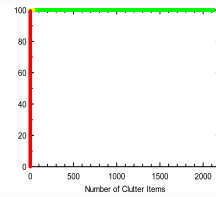David.Wright@CH2M.com
(919) 520 8673

Advanced Classification Demonstration/Validation
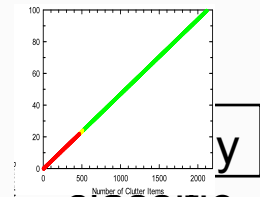
Receiver Operating Characteristic (ROC) Curves

Classifier Output:
Prioritized Dig List

Rank	Comment
1	
2	High confidence munition
3	
…	Can't make a decision
…	Can't make a decision
…	
…	
…	High confidence non-munition
…	
…	
…	
…	
N	

correctly classified as non-hazardous

Perfect Results

y

classified as non-hazardous

No Better Than Chance

- demonstrator threshold
- 100% of munitions correctly identified
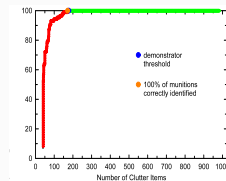
Validation program results:
- dig everything to assess technology